DRAFT HEALTH ADVISORY:

SAFE EATING GUIDELINES FOR FISH AND SHELLFISH FROM LAKE BERRYESSA AND PUTAH CREEK (NAPA, YOLO, AND SOLANO COUNTIES)

February 2006

Arnold Schwarzenegger
Governor
State of California

Alan C. Lloyd, Ph.D.
Agency Secretary
California Environmental Protection Agency

Joan E. Denton, Ph.D.
Director
Office of Environmental Health Hazard Assessment

DRAFT SAFE EATING GUIDELINES FOR FISH AND SHELLFISH FROM LAKE BERRYESSA AND PUTAH CREEK (NAPA, YOLO, AND SOLANO COUNTIES)

February 2006

Margy Gassel, Ph.D.
Susan Klasing, Ph.D.
Robert K. Brodberg, Ph.D.
Sue Roberts, M.S.

Pesticide and Environmental Toxicology Branch
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

LIST OF CONTRIBUTORS

Reviewers
Anna Fan, Ph.D.
George Alexeeff, Ph.D.

ACKNOWLEDGEMENTS

We would like to acknowledge Michelle Wood at the Central Valley Regional Water Quality Control Board, Jay Davis and Ben Greenfield at the San Francisco Estuary Institute for coordinating and providing data. We would also like to acknowledge Shaun M. Ayers, Ph.D. and Darell G. Slotton, Ph.D. for providing data for studies conducted by researchers at the University of California – Davis. Lastly, we would like to acknowledge staff from the California Department of Fish and Game and the State Water Resources Control Board for collecting, analyzing, and providing data through the Toxic Substances Monitoring Program and Surface Water Ambient Monitoring Program.

FOREWORD

This report provides guidelines for consumption of various fish species taken from water bodies in the Putah Creek watershed: Lake Berryessa (Napa County), and Putah Creek (Napa, Yolo, and Solano counties). These guidelines were developed as a result of findings of high mercury levels in fish tested from these water bodies and are provided to protect against possible adverse health effects from methylmercury as consumed from mercury-contaminated fish. This report provides background information and a description of the data and criteria used to develop the guidelines.

<u>For further information, contact:</u>

Pesticide and Environmental Toxicology Branch
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency
1515 Clay Street, 16th Floor
Oakland, California 94612
Telephone: (510) 622-3170

OR:

Pesticide and Environmental Toxicology Branch
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency
1001 I Street, P.O. Box 4010
Sacramento, CA 95812-4010
Telephone: (916) 327-7319

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Office of Environmental Health Hazard Assessment (OEHHA), formerly part of the Department of Health Services (DHS) but now in the California Environmental Protection Agency, issued a health advisory in 1987 for sport fish from Lake Berryessa (Napa County) based on mercury contamination in edible fish tissue collected from the lake (Appendix I). Since the advisory was issued, additional data have been collected for Lake Berryessa as well as for Putah Creek. The Central Valley Regional Water Quality Control Board (CVRWQCB) compiled a large dataset comprised of historical and more recently collected fish tissue data. OEHHA reviewed this dataset and compared it to the original datasets from which it was derived. Data suitable for issuing fish consumption advisories were selected out and verified before using them to update the advisory for Lake Berryessa, and to determine whether there may be potential adverse health effects associated with consuming sport fish from Putah Creek.

Mercury is a trace metal that can be toxic to humans and other organisms. Mercury occurs naturally in the environment, and is also redistributed in the environment as a result of human activities such as mining and the burning of fossil fuels. Once mercury is released into the environment, it cycles through land, air, and water. In aquatic systems, it undergoes chemical transformation to the more toxic organic form, methylmercury, which accumulates in fish and other organisms. More than 95 percent of the mercury found in fish occurs as methylmercury, which is a highly toxic form of the element. Consumption of fish is the major route of exposure to methylmercury in the United States. For more information on mercury, see Appendix II.

The critical target of methylmercury toxicity is the nervous system, particularly in developing organisms such as the fetus and young children. Significant methylmercury toxicity can occur to the fetus during pregnancy even in the absence of symptoms in the mother. In 1985, the United States Environmental Protection Agency (U.S. EPA) set a reference dose (that is the daily exposure likely to be without significant risks of deleterious effects during a lifetime) for methylmercury of $3x10^{-4}$ milligrams per kilogram of body weight per day (mg/kg-day), based on central nervous system effects (ataxia, or loss of muscular coordination; and paresthesia, a sensation of numbness and tingling) in adults. This reference dose (RfD) was lowered to $1x10^{-4}$ mg/kg-day in 1995 (and confirmed in 2001), based on developmental neurologic abnormalities in infants exposed *in utero*. Because OEHHA finds convincing evidence that the fetus is more sensitive than adults to the neurotoxic effects of mercury, but also recognizes that fish can play an important role in a healthy diet, OEHHA chooses to use both the current and previous U.S. EPA reference doses for two distinct population groups. In this advisory, the current RfD based on effects in infants will be used for women of childbearing age and children aged 17 years and younger. The previous RfD, based on effects in adults, will be used for women beyond their childbearing years and men.

Sufficient data were available to characterize the concentrations of mercury and issue safe eating guidelines for the following species and locations: channel catfish, white catfish, largemouth bass, rainbow trout, and chinook (king) salmon in Lake Berryessa; and channel catfish, white catfish, largemouth bass, Sacramento blackfish, Sacramento sucker, bluegill, carp, and crayfish in Putah Creek. Additional data for other species were considered and compared to federal advice to develop health-protective guidelines whenever possible. Mercury concentrations were generally lower in fish from Putah Creek compared to Lake Berryessa (for those species collected in both water bodies), and the data supported different advice for Lake Berryessa and Putah Creek for several of the species. Although it might be easier for fish consumers to follow the same guidelines for both water bodies, we chose to provide different guidelines as they generally allow for more consumption of fish from Putah Creek and thus provide a safer option for sport fish consumers. Anyone wishing to adhere to a simpler set of guidelines could choose to apply the more restrictive guidelines to both water bodies.

Mercury concentrations were compared to guidance tissue levels for methylmercury, which are designed so that individuals consuming no more than a preset number of meals should not exceed the RfD for this chemical. Evaluation of data and comparison with guidance tissue levels for methylmercury indicated that fish consumption guidelines were appropriate for Lake Berryessa and Putah Creek. "Safe eating guidelines" provide information to fish consumers as to which fish species have high mercury levels and whose consumption should be restricted or avoided altogether, as well as low-mercury fish that may be consumed frequently as part of a healthy diet. All individuals, especially women of childbearing age and children aged 17 years and younger, are advised to follow the safe eating guidelines to ensure that methylmercury ingestion does not exceed the reference dose. To help sport fish consumers achieve this goal, OEHHA has developed the guidelines contained in this report.

The revised guidelines for Lake Berryessa differ in several ways from the original advisory issued in 1987. The definition of the sensitive population has been expanded to include all women of childbearing age, in order to reduce the chance that mercury may accumulate in their bodies during the months and years preceding pregnancy. Additionally, the guidelines now include all children 17 years and younger in this sensitive population, as recent studies have shown that the still developing adolescent brain is more sensitive to toxins than is the adult brain. Whereas the previous advice instructed women who are pregnant or might become pregnant and young children not to eat any fish from Lake Berryessa, the new draft guidelines identify types of fish with lower levels of mercury that can be eaten by this population. With a wealth of data indicating that consumption of fish low in contaminants confers numerous health benefits to the fetus, children and adults, OEHHA's new safe eating guidelines provide for and encourage consumption of such fish by all consumers. The new draft guidelines also present the recommended consumption in meals per week or meals per month rather than in pounds of fish. Meal sizes should be adjusted to body weight as described in the advisory table.

For general advice on how to limit your exposure to chemical contaminants in sport fish (*e.g.*, eating smaller fish of legal size), see the California Sport Fish Consumption Advisories (http://www.oehha.ca.gov/fish.html) or Appendix III. Site-specific advice for other California water bodies can be found online at: http://www.oehha.ca.gov/fish/so_cal/index.html. Unlike the case for many organic contaminants, however, various cooking and cleaning techniques will not reduce the methylmercury content of fish.

SAFE EATING GUIDELINES
FISH CONSUMPTION AT LAKE BERRYESSA

Fish are nutritious and should be part of a healthy, balanced diet. It is important, however, to choose your fish wisely. OEHHA recommends that you choose fish to eat that are low in mercury, including the following fish caught from Lake Berryessa.

BEST CHOICES (Up to 3 times a week)
Women of childbearing age and children 17 years and younger:
There are no best choices for this population at Lake Berryessa
Women beyond childbearing age and men:
Trout or kokanee

Because some other types of fish from Lake Berryessa contain higher levels of mercury, OEHHA provides the following recommendations that you can follow to reduce the risks from exposure to methylmercury in fish.

CAUTION	
Women of childbearing age and children 17 years and younger:	
AVOID (No more than one meal a month)	Black bass, catfish, and chinook (king) salmon
EAT SPARINGLY (No more than one meal a week)	Bluegill or other sunfish, trout, or kokanee
Women beyond childbearing age and men:	
EAT SPARINGLY (No more than one meal a week)	Black bass, catfish, bluegill or other sunfish, or chinook (king) salmon

- **CONTACT WITH THE WATER IS SAFE.**
- **EAT SMALLER FISH OF LEGAL SIZE**. Fish accumulate mercury as they grow.
- **SERVE SMALLER MEALS TO CHILDREN**. Meal size is assumed to be 8 ounces for a 160-pound adult. If you weigh more or less than 160 pounds, add or subtract one ounce to your meal size, respectively, for each 20-pound difference in body weight.
- **DO NOT COMBINE FISH CONSUMPTION ADVICE**. If you eat multiple species or catch fish from more than one area, the recommended guidelines for different species and locations should not be combined.
- **CONSIDER YOUR TOTAL FISH CONSUMPTION**. Fish from many sources (including stores and restaurants) can contain elevated levels of mercury and other contaminants. If you eat commercial and/or sport fish with lower contaminant levels, you can safely eat more fish. The American Heart Association recommends that healthy adults eat at least two servings of fish per week. Commercial fish such as shrimp, king crab, scallops, farmed catfish, wild ocean salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest levels of mercury, as do the local fish in the "Best Choices" table.
- **FISH FROM MANY OTHER WATER BODIES ARE KNOWN OR SUSPECTED TO HAVE ELEVATED MERCURY LEVELS**. Not all water bodies in California have been tested. It is recommended that fish from places without an advisory be eaten sparingly.

SAFE EATING GUIDELINES
FISH CONSUMPTION AT PUTAH CREEK

Fish are nutritious and should be part of a healthy, balanced diet. It is important, however, to choose your fish wisely. OEHHA recommends that you choose fish to eat that are low in mercury, including the following fish caught from Putah Creek.

BEST CHOICES **(Up to 3 times a week)**
Women of childbearing age and children 17 years and younger:
Trout or Sacramento blackfish
Women beyond childbearing age and men:
Trout*, Sacramento blackfish*, bluegill or other sunfish, catfish (including bullheads), sucker, carp or goldfish, or crayfish

***** May be eaten daily by women beyond childbearing age and men

Because some other types of fish from Putah Creek contain higher levels of mercury, OEHHA provides the following recommendations that you can follow to reduce the risks from exposure to methylmercury in fish.

EAT SPARINGLY **(No more than one meal a week)**
Women of childbearing age and children 17 years and younger:
Black bass, bluegill or other sunfish, carp or goldfish, catfish (including bullheads), crappie, sucker, hitch, or crayfish
Women beyond childbearing age and men:
Black bass, crappie, or hitch

- **CONTACT WITH THE WATER IS SAFE.**
- **EAT SMALLER FISH OF LEGAL SIZE**. Fish accumulate mercury as they grow.
- **SERVE SMALLER MEALS TO CHILDREN**. Meal size is assumed to be 8 ounces for a 160-pound adult. If you weigh more or less than 160 pounds, add or subtract one ounce to your meal size, respectively, for each 20-pound difference in body weight.
- **DO NOT COMBINE FISH CONSUMPTION ADVICE**. If you eat multiple species or catch fish from more than one area, the recommended guidelines for different species and locations should not be combined.
- **CONSIDER YOUR TOTAL FISH CONSUMPTION**. Fish from many sources (including stores and restaurants) can contain elevated levels of mercury and other contaminants. If you eat commercial and/or sport fish with lower contaminant levels, you can safely eat more fish. The American Heart Association recommends that healthy adults eat at least two servings of fish per week. Commercial fish such as shrimp, king crab, scallops, farmed catfish, wild ocean salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest levels of mercury, as do the local fish in the “Best Choices” table.
- **FISH FROM MANY OTHER WATER BODIES ARE KNOWN OR SUSPECTED TO HAVE ELEVATED MERCURY LEVELS**. Not all water bodies in California have been tested. It is recommended that fish from places without an advisory be eaten sparingly.

Lake Berryessa and Putah Creek Sport Fish

Note: Images are not to scale

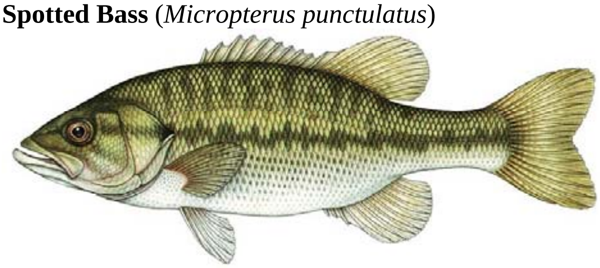
Largemouth Bass (*Micropterus salmoides*)

Duane Raver, USFWS

Smallmouth Bass (*Micropterus dolomieu*)

Duane Raver, USFWS

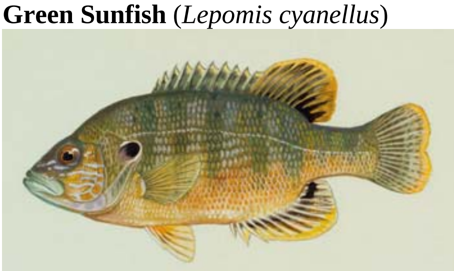
Spotted Bass (*Micropterus punctulatus*)



Bluegill (*Lepomis macrochirus*)

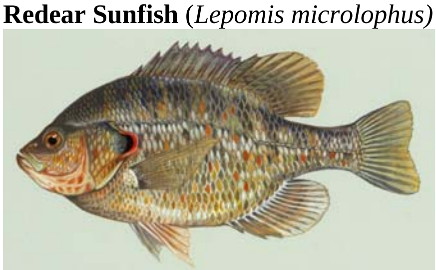
Duane Raver, USFWS

Green Sunfish (*Lepomis cyanellus*)



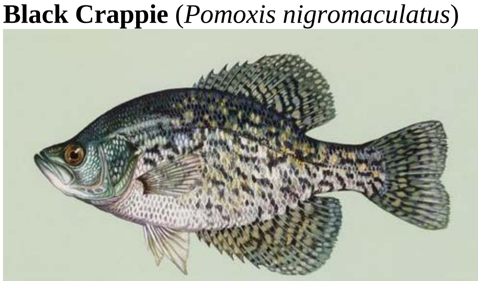
Duane Raver, USFWS

Redear Sunfish (*Lepomis microlophus)*



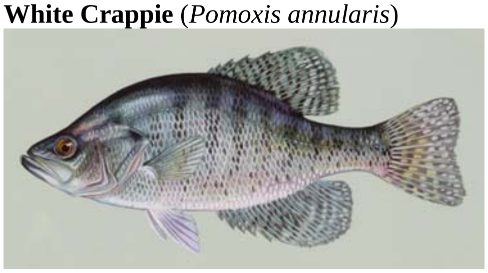
Duane Raver, USFWS

Black Crappie (*Pomoxis nigromaculatus*)



Duane Raver, USFWS

White Crappie (*Pomoxis annularis*)

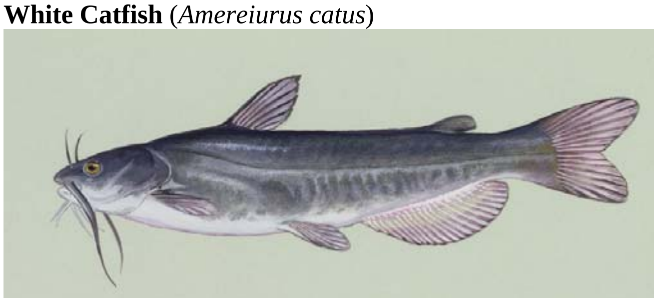


Duane Raver, USFWS

Channel Catfish (*Ictalurus punctalus*)

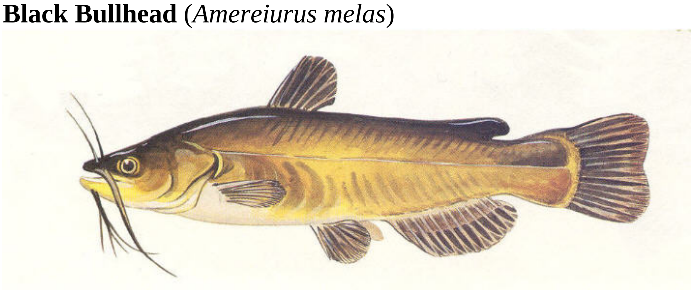
Duane Raver, USFWS

White Catfish (*Amereiurus catus*)



Duane Raver, USFWS

Black Bullhead (*Amereiurus melas*)



Duane Raver, USFWS

Sacramento Sucker (*Catostomus occidentalis*)

Rene' Reyes, USBR

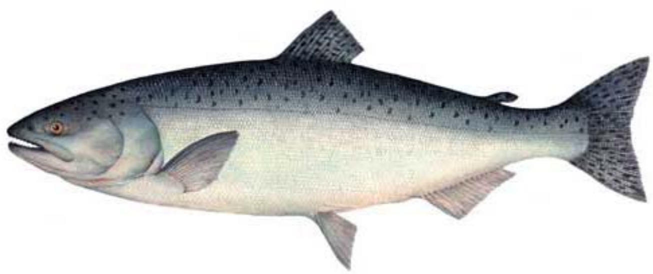
Rainbow Trout (*Oncorhynchus mykiss*)

Duane Raver, USFWS

Brown Trout (*Salmo trutta*)

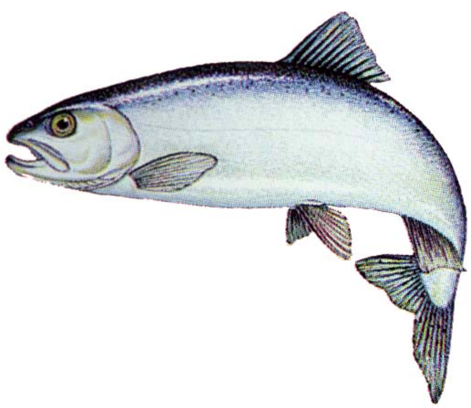
Duane Raver, USFWS

Chinook (King) Salmon (*Oncorhynchus tshawytscha*)



USBR

Kokanee (Sockeye Salmon) (*Oncorhynchus nerka*)



Courtesy Colorado Division of Wildlife

Sacramento Blackfish (*Orthodon microlepidotus*)

Zak Sutphin, USBR

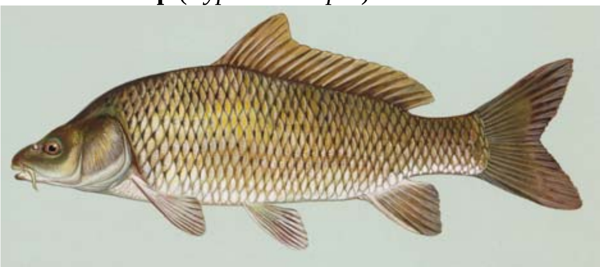
Hitch (*Lavinia exilicauda*)

Rene' Reyes, USBR

Sacramento Pikeminnow (*Ptychocheilus grandis*)

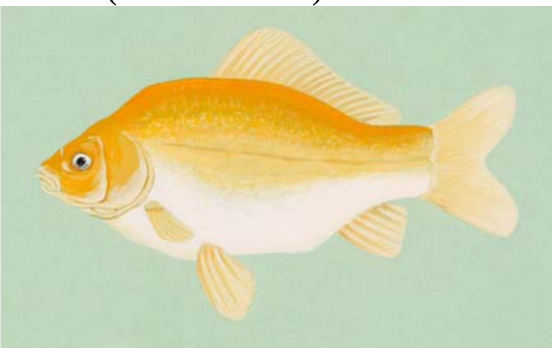
Rene' Reyes, USBR

Common Carp (*Cyprinus carpio*)



Duane Raver, USFWS

Goldfish (*Carassius auratus*)

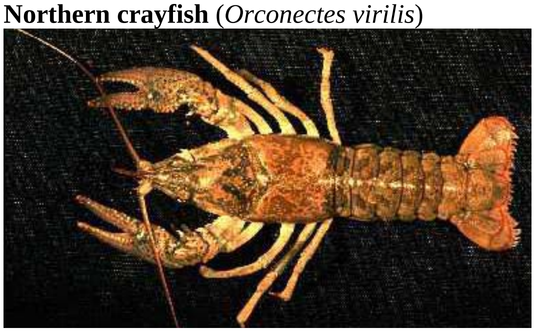


Duane Raver, USFWS

Red swamp crayfish (*Procambarus clarkii*)

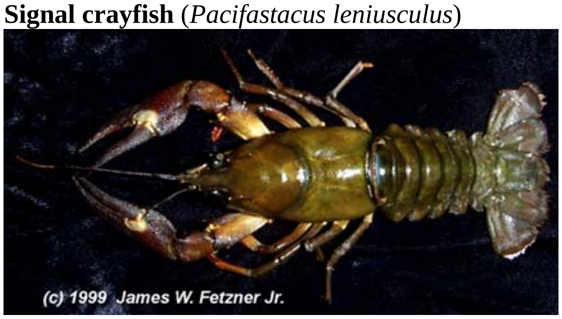
© Keith A. Crandall

Northern crayfish (*Orconectes virilis*)



© Keith A. Crandall

Signal crayfish (*Pacifastacus leniusculus*)



© James W. Fetzner Jr.

Signal crayfish showing variation

© 1995 David Holdich

INTRODUCTION

Elevated levels of mercury have been found in fish in a number of lakes and reservoirs in northern California. The Office of Environmental Health Hazard Assessment (OEHHA), formerly part of the Department of Health Services (DHS) but now in the California Environmental Protection Agency, issued a health advisory in 1987 for sport fish from Lake Berryessa (Napa County) based on mercury contamination in edible fish tissue collected from the lake (Stratton *et al.*, 1987; Appendix I). Additional fish tissues have subsequently been collected and analyzed from Lake Berryessa and Putah Creek (Napa, Yolo, and Solano counties) under various programs in California. In 2003, the Central Valley Regional Water Quality Control Board (CVRWQCB) organized these data, including historical and more recently collected data, into a single electronic database; some corrections were made to originally published data at that time. Subsequently, OEHHA received and reviewed the dataset, and data suitable for developing advisories were selected using criteria for minimum sizes, as described later in this report, and data reliability, as follows.

Each sample was verified using the original dataset or by discussion with investigators responsible for the data, as necessary, in order to address discrepancies that were found and correct errors (see Appendix IV for documentation of changes made by OEHHA to the dataset). Samples identified as potential duplicates were confirmed as duplicates and therefore eliminated, and weights and lengths that had been transposed for crayfish were corrected. OEHHA also found additional data on crayfish samples collected from Putah Creek by researchers at the University of California at Davis (UCD), and added these data to the corrected dataset (OEHHA, 2004) used for this advisory. OEHHA used the selected data to update the fish consumption advisory for Lake Berryessa, and to determine whether there might be potential adverse health effects associated with consuming sport fish from Putah Creek.

Mercury is a trace metal that can be toxic to humans and other organisms. Mercury occurs naturally in the environment, and exists in various forms including elemental or metallic mercury, inorganic, and organic mercury (ATSDR, 1999; IARC, 1993). Cinnabar ores, naturally rich in mercury, are common in northern California, and mercury was extensively mined in California in the 1800s and early 1900s. Mercury enters the environment from the breakdown of minerals in rocks and leaching from old mine sites. It is also emitted into air from mining deposits, the burning of fossil fuels, and other industrial sources, as well as from volcanic emissions. Mercury contamination thus occurs as a result of both natural and anthropogenic sources and processes. Once mercury is released into the environment, it cycles through land, air, and water. The deposition of mercury in aquatic ecosystems is a concern for public and environmental health because microorganisms (bacteria and fungi) in the sediments can convert inorganic mercury into organic methylmercury, a particularly toxic form of mercury. Once formed, methylmercury accumulates or “biomagnifies” in the aquatic food chain, reaching the highest levels in fish and other organisms at the top of the food web. Concentrations of methylmercury in fish tissues can therefore be orders of magnitude greater than concentrations in water. Consumption of fish is the principal route of exposure to methylmercury. Whether consumption of fish is harmful depends on the concentrations of methylmercury in the fish and the amount of fish consumed.

OEHHA is the agency responsible for evaluating public health impacts from chemical contamination of sport fish, and issuing advisories, when needed, for the state of California.

OEHHA's authorities to conduct these activities are based on mandates in the California Health and Safety Code, Section 59009, to protect public health, and Section 59011, to advise local health authorities; and the California Water Code Section 13177.5, to issue health advisories. Fish advisories developed by OEHHA are published in the California Sport Fishing Regulations of the California Department of Fish and Game (CDFG). OEHHA now emphasizes "safe eating guidelines" in these advisories in an effort to inform consumers of healthy choices in fish consumption as well as those that should be avoided or restricted.

In evaluating the fish tissue data for Lake Berryessa and Putah Creek, it was evident that some fish species in each of these water bodies had sufficient levels of mercury that could be a concern for frequent sport fish consumers. Because fish consumption guidelines were not currently in place for Putah Creek, safe eating guidelines were deemed appropriate for this water body. Additionally, the advisory for Lake Berryessa was updated taking all relevant data into account.

BACKGROUND

Lake Berryessa and Putah Creek are located in the California Coast Range in Napa County, Yolo County, and Solano County, California (Figures 1 and 2). Lake Berryessa is one of the largest man-made lakes in California with a surface area of approximately 20,000 acres and 165 miles of shoreline (Sak, 2005). The reservoir was formed as a result of the construction of Monticello Dam, which was completed in 1957 (Thayer, 2001). The United States Bureau of Reclamation and Solano County[1] manage and operate facilities at Lake Berryessa.

The lake provides year-round powerboat recreation and launching, and houseboat facilities, and is well known for trolling for lake trout, bass, and other game fish. There are several resorts and camping facilities located on the west side of the lake, and tourism and ranching are the primary industries in the area. Rainbow trout, brown trout, catfish, crappie, bluegill, carp, and salmon are all abundant in Lake Berryessa. Alien (introduced) fish species dominate the fish fauna (Moyle, 2001a). Beginning in 2000, the California Inland Fisheries Foundation, Incorporated (CIFFI) and CDFG initiated a pen-rearing program in Markley Cove with 5,000 rainbow trout and 5,000 chinook (king) salmon released that year. Chinook (king) salmon were not planted in Lake Berryessa the subsequent year or in 2002 because of a disease at the Feather River Fish Hatchery in Oroville. However, CDFG stocked 25,000 kokanee salmon in 2001, and 50,000 kokanee in 2002 (Bacher, 2002). Lake Berryessa is considered one of the best kokanee lakes in California, with the best fishing for kokanee beginning in early spring and lasting through fall; trophy size kokanee (up to two pounds) can be caught in the summer (Lentz, 2005). In addition, in December 2004, CIFFI planted 1,000 Eagle Lake trout to be released from the Markley Cove pens in the spring after reaching trophy size (CIFFI, 2005). Lake Berryessa is also known for excellent black bass fishing throughout the year, particularly in spring and fall. Some of the more productive areas for black bass are Spanish Flat, Markley Cove, and Putah Creek (Sak, 2005).

[1] The Bureau of Reclamation provides two large day use areas (Oak Shores and Smittle Creek), Capell Cove launch ramp, and many smaller dispersed day use areas. The seven resorts around the lake are managed by concessionaires under contract with the Bureau of Reclamation and provide camping, day use and boating facilities. Monticello Dam and Lake Berryessa, Putah Diversion Dam, and Putah South Canal headworks are operated and maintained by the Bureau of Reclamation, and managed under contract to the Solano County water agency.

Putah Creek, a tributary of the Sacramento River, originates in the Mayacmas Mountains on the western edge of Napa and Lake counties, about 30 miles northwest of Lake Berryessa, and terminates in the Yolo Bypass west of Sacramento. Below Monticello Dam, Putah Creek flows another 30 miles to the Yolo Bypass, a flood control channel that drains into the Sacramento River. Cold water released from the bottom of Lake Berryessa flows downstream about eight miles before being diverted into the Putah South Canal for use in Solano County and at UCD; a small amount is also allowed to continue downstream (Moyle, 2001a). The cold water supports an exceptional trout fishery (Moyle, 2001a). The Putah Creek Diversion Dam created a small reservoir known as Lake Solano, a slow-moving section of Putah Creek supplied year round with cold, oxygenated water from the bottom of Lake Berryessa. A recreational park is situated at Lake Solano[1], providing easy public fishing access. Lake Solano supports a fishery for brown and rainbow trout, which are stocked along with bass and catfish. Suckers are also common. Lower Putah Creek has experienced significant changes over time. Once a free-flowing waterway, it has been modified into an unnatural channel that supports diverse populations of both alien and native fishes, including small runs of salmon and other anadromous fishes (Moyle, 2003). As the creek flows through Winters, it becomes warmer, deeper, and slower, and suckers and pikeminnows become the dominant fishes (Moyle, 2001b). Alien fishes such as bass, green sunfish, bluegill, and carp are also common. The abundances of various fish species depend on flow; native species fare well during wet years, but alien species (*e.g.*, largemouth bass, bluegill, crappie, carp, goldfish, catfish, and black bullhead) usually predominate below Davis (Moyle, 2001b). The native Sacramento blackfish has also managed to thrive. During the highest and muddiest flows of winter, a few steelhead rainbow trout spawn below the diversion dam, and mix with resident trout (Moyle, 2001b).

Historically, the region was relatively sparsely populated, and the people were predominantly rural and agrarian (Moyle, 2003). Since 1950, however, a few small towns have grown into cities, with urban amenities and industries. In addition to agriculture, mining has also been important in the upper Putah Creek watershed. The East Mayacmas District was one of the principal mercury mining areas in the Putah Creek watershed between the 1870s and 1944 (U.S. Bureau of Mines, 1965). The area is also rich in geothermal springs, which are considered significant sources of mercury and other ores (Slotton et al., 2004; USGS, 1997).

Today, people residing in the region are chiefly of European origin; however, there are large Hispanic populations in some agricultural centers and in Winters, and several pockets of Asians and Native Americans (Cramer, 2001). Qualities that have attracted tourists to the area have also attracted retirees.

Native American peoples, who traditionally subsisted on fish and other local resources they harvested, once flourished in the Putah Creek region but were displaced and decimated by the influx of the Spanish, Mexican, and Russian peoples. Tribes that lived in the area historically and which most likely used the resources of the area included the Lake Miwok, and the Pomo and Mayacmas (sometimes called Wappo) peoples (Thayer, 2001; Lund, 2004). Today, members of a number of Indian tribes live on reservations or "rancherias" in the region. Most members of the Mishewal Wappo Tribe, which previously lived in Pope Valley and on Putah

[1] Lake Solano Park is owned by the Bureau of Reclamation, and Lake Solano has been administered as a recreational area by the County of Solano since 1971, with more than 200,000 visitors a year engaging in recreational activities both on and off the water.

Creek, among other locations, now live at the Wappo Rancheria in Sonoma County. Descendants of the Wintun Tribe include residents of the Cortina Rancheria in Colusa County and the Rumsey Rancheria in Yolo County (Alliance of CA Tribes/Tiller, 2005). Pomo Indians live at the Middletown Rancheria of Pomo Indians of California and at rancherias in nearby counties (*e.g.*, Mendocino County). Descendents of the Miwok also live throughout northern California including some at the Middletown Rancheria (Alliance of CA Tribes/Tiller, 2005).

The fish tissue dataset used in this report originated from several different sources for Lake Berryessa and Putah Creek, including the CALFED Mercury Project[1], the Sacramento River Watershed Program (SRWP)[2], the Toxic Substances Monitoring Program (TSMP) and Surface Water Ambient Monitoring Program (SWAMP)[3], CDFG, and researchers from UCD.[4]

Fish sampling at Lake Berryessa (Pope Creek Arm) and Putah Creek in 1999 was conducted as part of the CALFED Mercury Project. Monitoring conducted by SRWP included fish sampling in Putah Creek in 2000. Fish species sampled in these projects were bluegill, sucker, largemouth bass, white catfish, and brown trout. The CDFG Moss Landing Marine Laboratory (MLML) collected the fish samples using electroshocking boats and nets, such as Fyke nets. The samples from 1999 were reanalyzed after the laboratory discovered some methodological problems, and CALFED program samples were analyzed along with SRWP samples. Samples were prepared according to U.S. EPA (2000a) guidance: the skin was removed for channel catfish and white catfish; largemouth bass, pikeminnow, sucker, blackfish, bluegill, sunfish, crappie, and carp were scaled but analyzed with the skin on. Samples were measured (in total length) and weighed, and analyzed for mercury as individuals or composites using a Perkin Elmer Flow Injection Mercury System.

CDFG sampled fish at Lake Berryessa (including various arms) in 1982 and 1983, and in a small tributary to Markley Cove in 1984. CDFG also sampled fish from Putah Creek under TSMP in 1978, 1979, and SWAMP in 1999; and sampled Lake Berryessa for TSMP in 1985. Sampling was performed using electrofishing equipment, nets, and hook and line. Species collected included channel catfish, white catfish, largemouth bass, smallmouth bass, carp, sucker, chinook

---

[1] The CALFED Mercury Project was funded by the CALFED Bay-Delta Program to investigate mercury cycling in the Bay-Delta System.

[2] The SRWP, formed in 1996, is comprised of a wide coalition of stakeholders including representatives from government agencies, academia, local organizations, and the public. The program, which includes monitoring of potentially toxic pollutants in surface waters of the Sacramento River watershed, is funded primarily by the federal government and is administered by U.S. EPA Region IX. The Sacramento Regional County Sanitation District, Sacramento River Toxic Pollutant Control Program (SRTPCP), was instrumental in initiating the program and assists with funding. The San Francisco Estuary Institute (SFEI) coordinated fish monitoring.

[3] TSMP, a state water quality-monitoring program managed by the State Water Resources Control Board, was initiated in 1976 and continued until it was subsumed under SWAMP in 1997. CDFG collects and analyzes the samples.

[4] CALFED and SRWP data were obtained from Ben Greenfield at SFEI as electronic spreadsheets. TSMP and SWAMP data are maintained in OEHHA's data files after being downloaded from the SWRCB's web site at http://www.waterboards.ca.gov/programs/smw/index.html. Copies of handwritten fish tissue data for Lake Berryessa from the CDFG studies, as cited in: Wyels, W., Regional Mercury Assessment, California Regional Water Quality Control Board, Central Valley Region, staff report, March 1987, were mailed to OEHHA by Michelle Wood at CVRWQCB. Data from studies by UCD (Lower Putah Creek 1997-1998 Mercury Biological Distribution Study) were supplied by electronic mail by Shaun Ayers from UCD.

(king) salmon, and rainbow trout. Fish were measured (in fork length) and weighed, and analyzed as individuals or composites using skin-off muscle fillet[1]. Prior to 1997, composite samples were homogenized at the CDFG Water Pollution Control Laboratory (WPCL) and analyzed for total mercury by cold vapor atomic absorption spectrophotometry; since 1997, samples were analyzed for mercury and other trace metals by MLML.

Researchers from UCD sampled fish from numerous locations in Putah Creek in 1998 using electrofishing equipment, nets, or hook and line. Collected species included bluegill, carp, channel catfish, white catfish, hitch, largemouth bass, Sacramento pikeminnow, Sacramento sucker, rainbow trout, green sunfish, redear sunfish, black crappie, and white crappie, as well as numerous smaller fishes and bullfrog tadpoles, which are not relevant to this advisory. They also sampled three species of crayfish: red swamp crayfish (*Procambarus clarkii*), signal crayfish (*Pacifastacus leniusculus*), and northern crayfish (*Orconectes virilis*). Crayfish were analyzed as individuals; samples were measured (as carapace length) and weighed, and tail muscle was extracted and analyzed for total mercury. Mercury was measured as dry weight, and weight wet concentrations were calculated from the dry weight results using a consistent multiplier, in this case 0.2066 (Slotton, 2005). Fish were measured (in fork length) and weighed; boneless and skinless individual fillets of adult fish were analyzed by UCD for total mercury by cold vapor atomic absorption spectrophotometry.

In addition to analyses for mercury, limited analyses for organic chemicals (including pesticides and polychlorinated biphenyls or PCBs) were conducted for a few samples from Putah Creek. Under TSMP, two samples each of crayfish and sculpin from 1978 and 1979 were analyzed for organic contaminants. None of the chemicals were measured at levels of health concern, and most chemicals were not detected; however, OEHHA considers these samples too old to use for current health assessments because the analytical methodologies and detection limits have improved since the 1970s and 1980s. In 1999 and 2000, under SRWP, three composites of largemouth bass (18 fish) and two composites of sucker (eight fish) were analyzed for organic chemicals. Homogenized tissue was analyzed by gas chromatography, using mass spectrometry (GC/MS) for chlorinated hydrocarbon determination. Although these samples are not considered sufficient for a thorough evaluation of potential risks from exposure to pesticides or PCBs via consumption of fish from Putah Creek and Lake Berryessa, mean values of these chemicals for each species (data not shown) were below OEHHA's screening values (Brodberg and Pollock, 1999) used to determine whether further evaluation or site-specific advice should be considered. As such, only mercury data were considered for this advisory.

The data used in this evaluation were not collected specifically with the intention of developing fish consumption advisories; however, they can be used for that purpose providing certain sampling criteria are met. For example, U.S. EPA recommends a minimum of three replicate composite samples of three fish per composite (nine total fish) in order to begin assessing the magnitude of contamination at a site. U.S. EPA also recommends that at least two fish species be sampled per site. Although composite analysis is generally the most cost-efficient method of estimating the average concentration of chemicals in a fish species, individual sampling provides a better measure of the range and variability of contaminant levels in a fish population (U.S. EPA, 2000a). Using these guidelines, OEHHA believes that a minimum of three replicates

[1] TSMP has historically prepared samples as skin-off muscle fillets in accordance with guidance from OEHHA when the program was founded.

of three fish per composite or, preferably, nine individual fish samples of multiple species from each water body should be analyzed for the purpose of assessing the potential risks from consumption of fish from the water body. Species of fish that do not grow large (*e.g.*, sunfish) usually require more than three individuals per composite to provide sufficient tissue for analysis; this additional number of individuals will also make the samples more representative. When feasible, fish samples should be collected from multiple (legal or edible) sizes when a large size range exists in that species. Following this sampling protocol will allow estimation of the range and variation of contaminant concentrations at a particular site and derivation of a representative mean concentration for use in developing fish consumption advisories. However, more samples will provide a better estimate of the mean contaminant level in various fish species and are especially important for large water bodies.

Only legal and/or edible size fish and crayfish were included in this evaluation. Minimum size requirements are shown in Tables 1 and 2, and the case summaries in Appendix V present all data and indicate which of the data were selected and used in this evaluation. Because many of the samples in the dataset compiled by the CVRWQCB included undersized fish, a smaller subset of the data was used for developing the advice for these water bodies.

METHYLMERCURY TOXICOLOGY

Mercury is a metal found naturally in rocks, soil, air, and water that can be concentrated to high levels in the aquatic food chain by a combination of natural processes and human activities (ATSDR), 1999). The toxicity of mercury to humans is greatly dependent on its chemical form (elemental, inorganic, or organic) and route of exposure (oral, dermal, or inhalation). Methylmercury, an organic form, is highly toxic and can pose a variety of human health risks (NRC/NAS, 2000). Of the total amount of mercury found in fish muscle tissue, methylmercury comprises more than 95 percent (ATSDR, 1999; Bloom, 1992). Because analysis of total mercury is less expensive than that for methylmercury, total mercury is usually analyzed for most fish studies. In this study, total mercury was measured and assumed to be 100 percent methylmercury for the purposes of risk assessment.

Fish consumption is the major route of exposure to methylmercury in the United States (ATSDR, 1999). Almost all fish contain detectable levels of methylmercury, which, when ingested, is almost completely absorbed from the gastrointestinal tract (Aberg *et al.*, 1969; Myers *et al.*, 2000). Once absorbed, methylmercury is distributed throughout the body, reaching the largest concentration in kidneys. Its ability to cross the placenta as well as the blood brain barrier allows methylmercury to accumulate in the brain and fetus, which are known to be especially sensitive to the toxic effects of this chemical (ATSDR, 1999). In the body, methylmercury is slowly converted to inorganic mercury and excreted predominantly by the fecal (biliary) pathway. Methylmercury is also excreted in breast milk (ATSDR, 1999). The biological half-life of methylmercury is approximately 44 to 74 days in humans (Aberg *et al.*, 1969; Smith *et al.*, 1994), meaning that it takes approximately 44 to 74 days for one half of a single ingested dose of methylmercury to be eliminated from the body.

Human toxicity of methylmercury has been well studied following several epidemics of human poisoning resulting from consumption of highly contaminated fish (Japan) or seed grain (Iraq, Guatemala, and Pakistan) (Elhassani, 1982-83). The first recorded mass methylmercury poisoning occurred in the 1950s and 1960s in Minamata, Japan, following the consumption of fish contaminated by industrial pollution (Marsh, 1987). The resulting illness was manifested largely by neurological signs and symptoms such as loss of sensation in the hands and feet, loss of gait coordination, slurred speech, sensory deficits including blindness, and mental disturbances (Bakir *et al.*, 1973; Marsh, 1987). This syndrome was subsequently named Minamata Disease. A second outbreak of methylmercury poisoning occurred in Niigata, Japan, in the mid-1960s. In that case, contaminated fish were also the source of illness (Marsh, 1987). In all, more than 2,000 cases of methylmercury poisoning were reported in Japan, including more than 900 deaths (Mishima, 1992).

The largest outbreak of methylmercury poisoning occurred in Iraq in 1971-1972 and resulted from consumption of bread made from seed grain treated with a methylmercury fungicide (Bakir *et al.*, 1973). This epidemic occurred over a relatively short term (several months) compared to the Japanese outbreak. The mean methylmercury concentration of wheat flour samples was found to be 9.1 micrograms per gram (μg/g). Over 6,500 people were hospitalized, with 459 fatalities. Signs and symptoms of methylmercury toxicity were similar to those reported in the Japanese epidemic.

Review of data collected during and subsequent to the Japan and Iraq outbreaks identified the critical target of methylmercury as the nervous system and the most sensitive subpopulation as the developing organism (U.S. EPA, 1997). During critical periods of prenatal and postnatal structural and functional development, the fetus and children are especially susceptible to the toxic effects of methylmercury (ATSDR, 1999; IRIS, 1995). When maternal methylmercury consumption is very high, as happened in Japan and Iraq, significant methylmercury toxicity can occur to the fetus during pregnancy, with only very mild or even in the absence of symptoms in the mother. In those cases, symptoms in children were often not recognized until development of cerebral palsy and/or mental retardation many months after birth (Harada, 1978; Marsh *et al.*, 1980; Marsh *et al.*, 1987; Matsumoto *et al.*, 1964; Snyder, 1971).

The International Agency for Research on Cancer (IARC) has listed methylmercury compounds as possible human carcinogens, based on inadequate data in humans and limited evidence in experimental animals (increased incidence of tumors in mice exposed to methylmercury chloride) (IARC, 1993). Based on IARC's evaluation, OEHHA has administratively listed methylmercury compounds on the Proposition 65 list of chemicals known to the State of California to cause cancer. No estimate of the increased cancer risk from lifetime exposure has been developed for methylmercury.

DERIVATION OF REFERENCE DOSES FOR METHYLMERCURY

A reference dose (RfD) is an estimate, with uncertainty spanning perhaps an order of magnitude, of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime (IRIS, 1995). Reference doses are expressed in units of milligrams of the chemical of concern per kilogram of body weight per day (mg/kg-day). The estimate includes a safety factor to account for data uncertainty. The underlying assumption of a reference dose is that, unlike carcinogenic effects, there is a threshold dose below which certain toxic effects will not occur. The reference dose for a particular chemical is derived from review of relevant toxicological and epidemiological studies in animals and/or humans. These studies are used to determine a No-Observed-Adverse-Effect-Level (NOAEL; the highest dose at which no adverse effect is seen), a Lowest-Observed-

Adverse-Effect-Level (LOAEL; the lowest dose at which any adverse effect is seen), or a benchmark dose level (BMDL; a statistical lower confidence limit of a dose that produces a certain percent change in the risk of an adverse effect) (IRIS, 1995). Based on these values and the application of uncertainty factors to account for incomplete data and sensitive subgroups of the population, a reference dose is then generated. Exposure to a level above the RfD does not mean that adverse effects will occur, only that the possibility of adverse effects occurring has increased (IRIS, 1993).

The first U.S. EPA RfD for methylmercury was developed in 1985 and set at $3x10^{-4}$ mg/kg-day (U.S. EPA, 1997). This RfD was based, in part, on a World Health Organization report summarizing data obtained from several early epidemiological studies on the Iraqi and Japanese methylmercury poisoning outbreaks (WHO, 1976). WHO found that the earliest symptoms of methylmercury intoxication (paresthesias) were reported at blood and hair concentrations ranging from 200 to 500 micrograms per liter (μg/L) and 50-125 μg/g, respectively, in adults. In cases where ingested mercury dose could be estimated (based, for example, on mercury concentration in contaminated bread and number of loaves consumed daily), an empirical correlation between blood and/or hair mercury concentrations and onset of symptoms was obtained. From these studies, WHO determined that methylmercury exposure equivalent to long-term daily intake of 3-7 μg/kg body weight in adults was associated with an approximately 5 percent prevalence of paresthesias (WHO, 1976). U.S. EPA further cited a study by Clarkson *et al.* (1976) to support the range of blood mercury concentrations at which paresthesias were first observed in sensitive members of the adult population. This study found that a small percentage of Iraqi adults exposed to methylmercury-treated seed grain developed paresthesias at blood levels ranging from 240 to 480 μg/L. The low end of this range was considered to be a LOAEL and was estimated to be equivalent to a dosage of 3 μg/kg-day. U.S. EPA applied a ten-fold uncertainty factor to the LOAEL to reach what was expected to be the NOAEL. Because the LOAEL was observed in sensitive individuals in the population after chronic exposure, additional uncertainty factors were not considered necessary for exposed adults (U.S. EPA, 1997).

Although this RfD was derived on the basis of effects in adults, even at that time researchers were aware that the fetus might be more sensitive to methylmercury (WHO, 1976). It was not until 1995, however, that U.S. EPA had sufficient data from Marsh *et al.* (1987) and Seafood Safety (1991) to develop an oral RfD based on methylmercury exposures during the prenatal stage of development (IRIS, 1995). Marsh *et al.* (1987) collected and summarized data from 81 mother and child pairs where the child had been exposed to methylmercury *in utero* during the Iraqi epidemic. Maximum mercury concentrations in maternal hair during gestation were correlated with clinical signs in the offspring such as cerebral palsy, altered muscle tone and deep tendon reflexes, and delayed developmental milestones that were observed over a period of several years after the poisoning. Clinical effects incidence tables included in the critique of the risk assessment for methylmercury conducted by U.S. FDA (Seafood Safety, 1991) provided dose-response data for a benchmark dose approach to the RfD, rather than the previously used NOAEL/LOAEL method. The BMDL was based on a maternal hair mercury concentration of 11 parts per million (ppm). From that, an average blood mercury concentration of 44 μg/L was estimated based on a hair: blood concentration ratio of 250:1. Blood mercury concentration was, in turn, used to calculate a daily oral dose of 1.1 μg/kg-day, using an equation that assumed steady-state conditions and first-order kinetics for mercury. An uncertainty factor of 10 was applied to this dose to account for variability in the biological half-life of methylmercury, the lack of a two-generation reproductive study and insufficient data on the effects of exposure duration on developmental neurotoxicity and adult paresthesias. The oral RfD was then calculated to be $1x10^{-4}$ mg/kg-day, to protect against developmental neurological abnormalities in infants (IRIS, 1995). This fetal RfD was deemed protective of infants and sensitive adults.

The two previous RfDs for methylmercury were developed using data from high-dose poisoning events. Recently, the National Academy of Sciences was directed to provide scientific guidance to U.S. EPA on the development of a new RfD for methylmercury (NRC/NAS, 2000). Three large prospective epidemiological studies were evaluated in an attempt to provide more precise dose-response estimates for methylmercury at chronic low-dose exposures, such as might be expected to occur in the United States. The three studies were conducted in the Seychelles Islands (Davidson *et al.*, 1995, 1998), the Faroe Islands (Grandjean *et al.*, 1997, 1998, 1999), and New Zealand (Kjellstrom *et al.*, 1986, 1989). The residents of these areas were selected for study because their diets rely heavily on consumption of fish and marine mammals, which provide a continual source of methylmercury exposure (NRC/NAS, 2000).

Although estimated prenatal methylmercury exposures were similar among the three studies, subtle neurobehavioral effects in children were found to be associated with maternal methylmercury dose in the Faroe Islands and New Zealand studies, but not in the Seychelle Islands study. The reasons for this discrepancy were unclear; however, it may have resulted from differences in sources of exposure (marine mammals and/or fish), differences in exposure pattern, differences in neurobehavioral tests administered and age at testing, the effects of confounding variables, or issues of statistical analysis (NRC/NAS, 2000). The National Academy of Sciences report supported the current U.S. EPA RfD of $1x10^{-4}$ mg/kg-day for fetuses, but suggested that it should be based on the Faroe Islands study rather than Iraqi data.

U.S. EPA has recently published a new RfD document that arrives at the same numerical RfD as the previous fetal RfD, using data from all three recent epidemiological studies while placing emphasis on the Faroe Island data (IRIS, 2001). In order to develop an RfD, U.S. EPA used several scores from the Faroes data, rather than a single measure for the critical endpoint, as is customary (IRIS, 2001). U.S. EPA developed BMDLs utilizing test scores for several different neuropsychological effects with cord blood as the preferred biomarker. The BMDLs for different neuropsychological effects in the Faroes study ranged from 46 to 79 μg mercury/liter blood. U.S. EPA then chose a one-compartment model for conversion of cord blood to ingested maternal dose, which resulted in estimated maternal mercury exposures of 0.857-1.472 μg/kg-day (IRIS, 2001). An uncertainty factor of ten was applied to the oral doses corresponding to the range of BMDLs to account for inter-individual toxicokinetic variability in ingested dose estimation from cord-blood mercury levels and pharmacodynamic variability and uncertainty, leading to an RfD of $1x10^{-4}$ mg/kg-day (IRIS, 2001). In support of this RfD, U.S. EPA found that benchmark dose analysis of several neuropsychological endpoints from the Faroe Island and New Zealand studies, as well as an integrative analysis of all three epidemiological studies, converged on an RfD of $1x10^{-4}$ mg/kg-day (IRIS, 2001). U.S. EPA (IRIS, 2001) now considers this RfD to be protective for all populations. However, in their joint federal advisory for mercury in fish, U.S. EPA and FDA only apply this RfD to women who are pregnant or might become pregnant, nursing mothers, and young children (U.S. EPA, 2004).

OEHHA finds that there is convincing evidence that the fetus is more sensitive than adults to the neurotoxic and subtle neuropsychological effects of methylmercury. As noted previously, during the Japanese and Iraqi methylmercury poisoning outbreaks, significant neurological toxicity occurred to the fetus even in the absence of symptoms in the mother. In later epidemiological studies at lower exposure levels (*e.g.*, in the Faroe Islands), these differences in maternal and fetal susceptibility to methylmercury toxicity were also observed. Recent evidence has shown that the nervous system continues to develop through adolescence (see, for example, Giedd *et al.*, 1999; Paus *et al.*, 1999; Rice and Barone, 2000). As such, it is likely that exposure to a neurotoxic agent during this time may damage neural structure and function (Adams *et al.*, 2000), which may not become evident for many years (Rice and Barone, 2000). Thus, OEHHA considers the RfD based on subtle neuropsychological effects following fetal exposure to be the best estimate of a protective daily exposure level for pregnant or nursing females and children aged 17 years and younger.

OEHHA also recognizes that fish can play an important role in a healthy diet, particularly when it replaces other higher-fat sources of protein. Numerous human and animal studies have shown that fish oils have beneficial cardiovascular and neurological effects (see, for example, Harris and Isley, 2001; Iso *et al.*, 2001; Mori and Beilin, 2001; Daviglus *et al.*, 1997; von Schacky *et al.*, 1999; Valagussa *et al.*, 1999; Moriguchi *et al.*, 2000; Lim and Suzuki, 2000; Cheruka *et al.*, 2002). Nonetheless, the hazards of methylmercury that may be present in fish, particularly to developing fetuses and children, cannot be overlooked. When contaminants are present in a specific food that can be differentially avoided, it is not necessary to treat all populations in the most conservative manner to protect the most sensitive population. Sport fish consumption advisories are such a case. Exposure advice can be tailored to specific risks and benefits for populations with different susceptibilities so that each population is protected without undue burden to the other. Fish consumption guidelines utilize the best scientific data available to provide the most relevant advice and protection for all potential consumers.

In an effort to address the risks of methylmercury contamination in different populations as well as the cardiovascular and neurological benefits of fish consumption, two separate RfDs will be used to assess risk for different population groups. OEHHA has formerly used separate methylmercury RfDs for adults and pregnant females to formulate advisories for methylmercury contamination of sport fish (Stratton *et al.*, 1987). Additionally, most states issue separate consumption advice for sensitive (*e.g.*, children) and general population groups. OEHHA chooses to use both the current and previous U.S. EPA references doses for two distinct population groups. For these safe eating guidelines, the current RfD of 0.1 μg/kg-day, based on effects in infants will be used for women of childbearing age and children aged 17 years and younger. The previous RfD of 0.3 μg/kg-day, based on effects in adults, will be used for women beyond their childbearing years and men.

MERCURY LEVELS IN FISH FROM LAKE BERRYESSA AND PUTAH CREEK

Mercury concentrations in fish and other biota are dependent, in general, on the mercury level of the environment in which they reside. However, there are many factors that affect the accumulation of mercury in fish tissue. Fish species and age (as inferred from length) are known to be important determinants of tissue mercury concentration (WHO, 1989; 1990). Fish at the highest trophic levels (*i.e.*, predatory fish) generally have the highest levels of mercury. Additionally, because the biological half-life of methylmercury in fish is much longer (approximately 2 years) than in mammals, tissue concentrations increase with increased duration of exposure (Krehl, 1972; Stopford and Goldwater, 1975; Tollefson and Cordle, 1986). Thus, with increasing age (length) within a given species, tissue methylmercury concentrations are expected to increase. In addition to differences in species, size, and water mercury concentration, the accumulation of mercury in fish is also dependent on environmental differences in pH, redox potential, temperature, alkalinity, buffering capacity, suspended sediment load, and geomorphology in individual water bodies (Andren and Nriagu, 1979; Berlin, 1986; WHO, 1989).

Chemical concentrations for the data presented below are reported in wet weight. Arithmetic means, rather than geometric means, were used to represent the central tendency (average) of mercury concentrations for all species in this report. In general, arithmetic means for environmental chemical exposures are more health-protective than geometric means, and are commonly used in human health risk assessments. The mean mercury concentrations, lengths, and sample sizes for each species collected and analyzed are presented in Table 1 for Lake Berryessa and in Table 2 for Putah Creek. Complete descriptive statistics for each fish or shellfish species in this study can be found in Appendices VI and VII; individual mercury concentrations and fish lengths from which species means were generated can be found in Appendix V. All fish lengths that were reported in fork length were converted to total length for the purpose of calculating mean lengths; conversion factors for estimating total length from measured fork lengths were developed for each species by OEHHA based on the degree of the angle in the fork of the tail fin. The lengths as originally reported, however, are included in Appendix V.

Combining data for water bodies in the same watershed can be advantageous because this increases available results for individual species and leads to consistent advice. Combining data is not appropriate, however, when mercury concentrations in fish from different water bodies are so different that they might result in significantly different advice if considered independently. Comparison of the mean mercury concentrations for two of the species collected in sufficient numbers from Lake Berryessa and Putah Creek (*i.e.*, channel catfish and white catfish) showed differences in mercury concentrations that would warrant different and less restrictive advice for Putah Creek than for Lake Berryessa. Therefore, Putah Creek and Lake Berryessa were considered separately when developing safe eating guidelines.

To confirm the differences in mercury concentrations in catfish from Putah Creek and Lake Berryessa using a statistical approach, multiple regression correlation was used to test for the influence of site. Mercury was log-transformed, and length and length-square was selected as the covariate, since a curve analysis indicated a quadratic model as the best fit for these data. In channel catfish, length explained about 26 percent of the variance ($p < 0.001$). After controlling for length, site (Putah Creek versus Lake Berryessa) accounted for an additional 19 percent of unique variance ($p < 0.001$; Figure 3). There was no significant length-site interaction. Similar results were found for white catfish. In this species, length accounted for about 77 percent of the variance, and after controlling for length, site explained an additional 17 percent of unique variance ($p < 0.001$; Figure 4). There was no significant length-site interaction. These results provide statistical support for treating Putah Creek and Lake Berryessa as separate water bodies. Most other species showed the same trend for lower mercury concentrations in Putah Creek compared to Lake Berryessa, although the sample sizes were too small to consider the results representative of the population or to conduct statistical analyses. Because the mean mercury concentrations for the catfish species call for different levels of advice at the two water bodies, and the results of the statistical analysis indicated that location (Putah Creek versus Lake Berryessa) contributed significantly to the variance in mercury concentration, consumption guidelines were developed for each water body separately. This approach did not always lead to different advice. For example, largemouth bass did not show differences in mean mercury concentrations that would warrant different advice for each water body for women of childbearing age and children, and therefore, the same advice level is provided for this population for black bass from both water bodies.

An adequate number of samples was available for the following species and locations: channel catfish, white catfish, largemouth bass, rainbow trout, and chinook (king) salmon in Lake Berryessa; and channel catfish, white catfish, largemouth bass, Sacramento blackfish, Sacramento sucker, bluegill, and carp in Putah Creek. Mean mercury concentrations in legal and/or edible-size fish from Lake Berryessa, based on fish species with adequate sample sizes, ranged from 0.17 ppm in rainbow trout to 0.77 ppm in white catfish. In Putah Creek, the values ranged from 0.09 ppm in Sacramento blackfish to 0.46 ppm in largemouth bass.

In several cases, related species were sampled from the same water body. For example, at Lake Berryessa, both white catfish and channel catfish were collected, each in adequate numbers although there were many more channel catfish. There were also 42 largemouth bass and one smallmouth bass, for a total of 43 “black bass.” Combining data for closely related species in the same water body is practical because it increases the sample size for related species, but more importantly, results in simpler and more consistent guidelines that are easier to remember and follow. In some cases, related species can fall into different advice categories even when the mean mercury concentrations are similar. Issuing different advice for similar, related species, however, would complicate communication of the advisory message. Furthermore, fishers and fish consumers may not always distinguish closely related species, so using an average concentration from combined related species is a reasonable approach that can assist consumers; this approach has been used in the fish consumption guidelines for Lake Berryessa and Putah Creek. For Lake Berryessa, the overall mean mercury concentration for channel catfish and white catfish combined (0.56 ppm) and the overall mean for largemouth bass and smallmouth bass (0.76 ppm) were used to set guidelines for each of these species groups.

In Putah Creek, several types of sunfish were collected: bluegill, redear sunfish, green sunfish, and one hybrid sunfish; the mean mercury concentrations for each species were similar but did not all fall in the same advice category. Furthermore, all of these species except bluegill were collected in insufficient numbers. To simplify the advice, the overall mean mercury concentration in these species combined (0.14 ppm) was used to set safe eating guidelines for sunfish. Using the combined average concentration allows inclusion of related species with smaller sample sizes in the consumption guidelines and is likely to provide more reliable representations of the chemical concentration in these populations than measurements taken from only a few fish. Trout (rainbow and brown) and catfish (white and channel) from Putah Creek were also evaluated in this way. The overall mean mercury concentrations for trout (0.07 ppm) and for catfish (0.07 ppm) from Putah Creek are shown in Table 2; species from Lake Berryessa are summarized in Table 1.

Three species of crayfish were also sampled from Putah Creek: red swamp crayfish, northern crayfish, and signal crayfish. The mean mercury concentrations for each species are shown in Table 2. Although each crayfish species is distinguished by physical characteristics, it can be difficult to do so, especially since the coloration of individuals can change. As with fish species, advice is based on the overall mean mercury concentration (0.21 ppm) for all three species (Table 2).

Although many of the fish species that occur in Lake Berryessa and Putah Creek were sampled, some species (and combined species groups) did not meet OEHHA's minimum sample size criterion of nine fish. These species included bluegill and carp from Lake Berryessa, and crappie, hitch, and Sacramento pikeminnow at Putah Creek. Additionally, no samples were obtained of spotted bass, brown trout, Eagle lake trout, Sacramento pikeminnow, crappie, or kokanee from Lake Berryessa, or salmon, steelhead, goldfish, or black bullhead from Putah Creek, species that are commonly found in these water bodies.

Fish consumption guidelines are appropriate whenever there are sufficient data to suggest that adverse health effects may occur from unrestricted consumption of individual fish species at certain sites. When sample size for a particular species or species group from a water body is too small to assure a representative sample, that is, when there are less than nine individual or three composite samples for a given species at a water body, consumers may choose to exercise caution in eating these fish, but the data are not adequate for issuing specific advice.

U.S. EPA (2004), in cooperation with the U.S. Food and Drug Administration (FDA), provided guidelines for women who are pregnant or might become pregnant, nursing women, and young children to follow for fish caught from local water bodies without an advisory. Therefore, the federal guidelines were considered for fish from Lake Berryessa and Putah Creek that did not meet the minimum sample size criteria, as discussed below.

GUIDELINES FOR FISH CONSUMPTION FOR LAKE BERRYESSA AND PUTAH CREEK

Guidance tissue levels for chemicals of concern in fish have been developed that relate the number and size of recommended fish meals to methylmercury concentrations found in fish (Table 3). OEHHA has developed guidance tissue levels for mercury or methylmercury (Brodberg and Klasing, 2003) similar to risk-based consumption limits recommended by U.S. EPA (U.S. EPA, 2000b). These guidance values were designed so that individuals consuming no more than a preset number of meals should not exceed the RfD for methylmercury. Meal sizes are based on a standard 8-ounce (227 grams) portion of uncooked fish (approximately 6 ounces after cooking) for adults who weigh approximately 70 kilograms (equivalent to 154 pounds). OEHHA begins issuing consumption advice for specific waterbodies if data indicate that consumption of twelve meals per month would result in the consumer exceeding the reference dose for the contaminant in the fish, (*e.g.*, mercury). Consumption of twelve meals per month corresponds to a representative upper bound consumption rate for frequent sport fish consumers in California (Gassel, 2001). For sensitive populations, guidelines begin when the methylmercury concentration exceeds 0.08 ppm. Tissue guidance levels for women beyond their childbearing years and men are approximately three times higher than for sensitive populations because of the three-fold higher RfD level used for this population group.

Comparison of mean mercury concentrations in fish and shellfish species from Lake Berryessa and Putah Creek with guidance tissue levels for mercury indicated that issuance of fish consumption advice is appropriate for these water bodies. Safe eating guidelines for all species with a minimum of nine individuals per water body were derived on the basis of the guidance tissue levels. The measured concentrations in species with insufficient data (bluegill and carp from Lake Berryessa and crappie, hitch, and Sacramento pikeminnow from Putah Creek) were also compared to the guidance tissue levels to determine whether the mean measured concentrations in each of these species would be consistent with the joint Federal Advisory for Mercury in Fish issued by U.S. EPA and FDA. The Federal Advisory (U.S. EPA, 2004) recommends that women who are pregnant or might become pregnant, nursing mothers, and young children limit their consumption of fish caught by family and friends in local waters to one meal a week, when no other advice is available. Bluegill at Lake Berryessa, and crappie and hitch from Putah Creek were consistent with the federal advisory for women of childbearing age and children and, therefore, were included in the safe eating guidelines despite their small sample sizes. However, carp from Lake Berryessa and Sacramento pikeminnow from Putah Creek had mean mercury concentrations that exceeded the guidance tissue level corresponding to the federal advice, and therefore, the federal advisory was not considered health protective or appropriate for these two species. The limited sample sizes for bluegill at Lake Berryessa, and for crappie and hitch from Putah Creek were not adequate for determining whether women beyond childbearing age and men could safely eat these fish more frequently and therefore, the federal guidelines were applied for this population as well. Consumption of one meal of fish a week falls into the "Eat Sparingly" category in OEHHA's advisory tables.

Species for which no data were collected included spotted bass, crappie, brown trout, Eagle lake trout, and kokanee from Lake Berryessa. Mercury concentrations in spotted bass in other water bodies are similar to those of other bass species, such as largemouth bass (Klasing and Brodberg, 2003), likely due to similarities in feeding habits and trophic level as well as taxonomic relationship (largemouth, smallmouth, and spotted bass are members of the same genus *Micropterus*). Therefore, OEHHA considers spotted bass part of the "black bass" species group and consumers can apply the guidelines for black bass in these advisories to spotted bass.

There were no data for crappie from Lake Berryessa, and no closely related species; therefore, it was not possible to issue specific advice. Samples sizes of crappie collected from Putah Creek were small. Although the mercury concentrations in those samples were consistent with the federal advisory, mercury concentrations in general were higher at Lake Berryessa than at Putah Creek. Therefore, it would be wise for consumers to avoid eating crappie from Lake Berryessa or eat them infrequently.

Rainbow trout was the only trout species sampled at Lake Berryessa. Additional information about this and other species of trout was used to develop the guidelines for trout. There are many species of trout in California, and some species are also raised in hatcheries and planted in reservoirs and creeks including Lake Berryessa and Putah Creek. Rainbow trout are highly variable in color and the genetic relationships between them and other salmonid species is complex and uncertain; hybridization between species also confuses the issue (Moyle, 2002). Many of the rainbow trout and brown trout in Lake Berryessa and in Putah Creek are hatchery-raised fish that have been planted, and Eagle lake trout were also recently planted at Lake Berryessa. It could be difficult (and unusual) for fishers to identify trout by species or distinguish hatchery trout from resident trout. The feeding habits of rainbow trout, Eagle Lake trout, and brown trout are generally similar, although at the largest sizes, brown trout tend to be more piscivorous. However, data from Putah Creek from more moderate-sized rainbow trout and brown trout showed them to be similarly low in mercury concentrations. Given these similarities and the difficulty in distinguishing species, the guidelines provided for trout can be followed for all types of trout caught in these water bodies. Furthermore, kokanee, which have also been planted in Lake Berryessa are a non-anadromous variation of sockeye salmon, and are also closely related to rainbow trout. They feed mainly on zooplankton, although in some locations they may consume small crustaceans, such as copepods, and terrestrial insects (Moyle, 2002). Therefore, because the trophic level of kokanee is similar to (if not lower than) trout, and they belong to the same genus as rainbow trout, the safe eating guidelines for trout would also be appropriate for kokanee.

There were no data for goldfish or black bullhead, two common species in Putah Creek, however each species was compared to close relatives. Although carp and goldfish have been placed in different genera, they can hybridize, which suggests sufficient genetic similarity to produce viable offspring. Both species are omnivorous, however, carp feed more on animals than on plants and would therefore be assigned a higher trophic level than would goldfish, which eat mainly algae, detritus and planktonic organisms. Consequently, the guidelines for carp should be sufficiently protective for consumption of goldfish and could be used by goldfish consumers.

Black bullheads are closely related to white catfish (both in the genus *Ameirus*). In fact, bullheads are more closely related to white catfish than are channel catfish (genus *Ictalurus*). They are all omnivorous bottom feeders, and while prey can vary by water body, the trophic level for each species is similar enough that consumption guidelines would be applicable across species. Therefore, black bullheads were included in the catfish species group.

Consumers should be informed of the potential hazards from eating fish with high mercury concentrations, particularly those hazards relating to the developing fetus and children, as well as the fish species that contain less mercury and therefore provide better options when choosing fish to eat. All individuals, especially women of childbearing age and children aged 17 years and younger, are advised to limit their consumption of high-mercury fish to reduce methylmercury ingestion to a level as close to the RfD as possible. In addition, fish consumers are encouraged to eat fish species with lower levels of mercury in order to enjoy the benefits from eating fish. Recreational fishers may opt to practice catch-and-release for species that have high levels of mercury.

The revised guidelines for Lake Berryessa differ in several ways from the original advisory issued in 1987. The definition of the sensitive population has been expanded to include all women of childbearing age, in order to reduce the chance that mercury may accumulate in their bodies during the months and years preceding pregnancy. Additionally, the guidelines now include all children 17 years and younger in this sensitive population, as recent studies have shown that the still developing adolescent brain is more sensitive to toxins than is the adult brain. Whereas the previous advice instructed women who are pregnant or might become pregnant and young children not to eat any fish from Lake Berryessa, the new draft guidelines identify types of fish with lower levels of mercury that can be eaten by this population. With a wealth of data indicating that consumption of fish low in contaminants confers numerous health benefits to the fetus, children and adults, OEHHA's new safe eating guidelines provide for and encourage consumption of such fish by all consumers. The new draft guidelines also present the recommended consumption in meals per week or meals per month rather than in pounds of fish. Meal sizes should be adjusted to body weight as described in the advisory table. The safe eating guidelines are provided below.

Recommendations for Lake Berryessa

It is recommended that **women of childbearing age and children aged 17 years and younger** avoid eating the following species from **Lake Berryessa**: black bass including largemouth bass, smallmouth bass, or spotted bass; catfish including channel catfish or white catfish; and chinook (king) salmon. The following species combined can be eaten sparingly: bluegill or other sunfish; trout including rainbow trout, brown trout, or Eagle lake trout; or kokanee.

For **women beyond childbearing age and men**, the following species from **Lake Berryessa** can be eaten sparingly: black bass including largemouth bass, smallmouth bass, or spotted bass; catfish including white catfish or channel catfish; bluegill or other sunfish; or chinook (king) salmon. The best choices (fish species that can be eaten two or three times a week) are trout including rainbow trout or brown trout; or kokanee.

Recommendations for Putah Creek

At **Putah Creek**, it is recommended that **women of childbearing age and children aged 17 years and younger** eat the following species sparingly: black bass including largemouth bass, smallmouth bass, or spotted bass; catfish including channel catfish, white catfish, or bullheads; bluegill or other sunfish; carp or goldfish; crappie including black or white crappie; sucker; hitch; or crayfish. Best choices are trout or Sacramento blackfish.

For **women beyond childbearing age and men** eating fish from **Putah Creek**, black bass including largemouth bass, smallmouth bass, or spotted bass; crappie, or hitch can be eaten sparingly. Best choices are trout including rainbow trout or brown trout; Sacramento blackfish; bluegill or other sunfish; catfish including channel catfish, white catfish, or bullheads; sucker; carp or goldfish; or crayfish. Of these, the mercury concentrations in trout and blackfish were low enough for daily consumption of one or the other of these species.

It is very important to note that if an individual consumes multiple species or catches fish from more than one site, the recommended guidelines for different species and locations should not be combined (*i.e*., added). If a person eats a meal of fish from the one meal per month category, he or she should not eat any other fish for at least one month. For fish in the meal per week category, an individual can eat one species of fish one week, and the same or a different species from the meal per week category the next week. For example, if a pregnant woman were to eat a meal from the meal per week category (e.g., bluegill from Putah Creek), it would be best if she did not eat another meal of fish that week. She could eat another meal of fish from the meal per week category the following week from Putah Creek or another site where some fish have the same advice, but should not eat any meals from the more restrictive meal a month category in the same one-month period. As indicated by the advisory tables, the best choice for this pregnant woman would be to eat two meals a week of trout because she would be choosing a type of fish very low in mercury, and additionally, this regular consumption of low-mercury fish as recommended by the American Heart Association (2002; 2005) for a healthy heart could also provide neurological advantages to the developing fetus (Oken *et al*., 2005; Cohen, et al., 2005). Fish species in the three meals per week category can be combined in the same week.

OEHHA also recommends that **women of childbearing age and children aged 17 and younger** follow the Joint Federal Advisory for Mercury in Fish for **commercial** fish (U.S. EPA, 2004, see http://www.epa.gov/waterscience/fishadvice/advice.html). This advisory recommends that these individuals do not eat shark, swordfish, king mackerel, or tilefish because of the high levels of mercury in these species. The federal advisory also states that these individuals can safely eat up to an average of 12 ounces (two average meals) per week of a variety of other cooked fish purchased at stores or restaurants such as shrimp, canned light tuna, wild salmon, pollock, or (farm-raised) catfish. Albacore ("white") tuna is known to contain more mercury than canned light tuna; it is therefore recommended that no more than six ounces of albacore tuna be consumed per week. Also, if 12 ounces of cooked fish from a store or restaurant are eaten in a given week, then OEHHA recommends that sport fish caught at Lake Berryessa, Putah Creek, or other California water bodies should not be consumed in the same week. One or both of these two meals could include, as an alternative, fish from the "Best Choices" category.

For general advice on how to limit your exposure to chemical contaminants in sport fish (*e.g.*, eating smaller fish of legal size), see Appendix III. Unlike the case for many fat-soluble organic contaminants (*e.g.*, DDTs and PCBs), however, various cooking and cleaning techniques will not reduce the methylmercury content of fish. Meal sizes should be adjusted to body weight as described in the advisory table. The complete recommendations (safe eating guidelines) for consumption of fish from Lake Berryessa and Putah Creek are presented in the tables below.

SAFE EATING GUIDELINES
FISH CONSUMPTION AT LAKE BERRYESSA

Fish are nutritious and should be part of a healthy, balanced diet. It is important, however, to choose your fish wisely. OEHHA recommends that you choose fish to eat that are low in mercury, including the following fish caught from Lake Berryessa.

BEST CHOICES **(Up to 3 times a week)**
Women of childbearing age and children 17 years and younger:
There are no best choices for this population at Lake Berryessa
Women beyond childbearing age and men:
Trout or kokanee

Because some other types of fish from Lake Berryessa contain higher levels of mercury, OEHHA provides the following recommendations that you can follow to reduce the risks from exposure to methylmercury in fish.

CAUTION	
Women of childbearing age and children 17 years and younger:	
AVOID **(No more than one meal a month)**	Black bass, catfish, or chinook (king) salmon
EAT SPARINGLY **(No more than one meal a week)**	Bluegill or other sunfish, trout, or kokanee
Women beyond childbearing age and men:	
EAT SPARINGLY **(No more than one meal a week)**	Black bass, catfish, bluegill or other sunfish; or chinook (king) salmon

- **CONTACT WITH THE WATER IS SAFE.**
- **EAT SMALLER FISH OF LEGAL SIZE**. Fish accumulate mercury as they grow.
- **SERVE SMALLER MEALS TO CHILDREN**. Meal size is assumed to be 8 ounces for a 160-pound adult. If you weigh more or less than 160 pounds, add or subtract one ounce to your meal size, respectively, for each 20-pound difference in body weight.
- **DO NOT COMBINE FISH CONSUMPTION ADVICE**. If you eat multiple species or catch fish from more than one area, the recommended guidelines for different species and locations should not be combined.
- **CONSIDER YOUR TOTAL FISH CONSUMPTION**. Fish from many sources (including stores and restaurants) can contain elevated levels of mercury and other contaminants. If you eat commercial and/or sport fish with lower contaminant levels, you can safely eat more fish. The American Heart Association recommends that healthy adults eat at least two servings of fish per week. Commercial fish such as shrimp, king crab, scallops, farmed catfish, wild ocean salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest levels of mercury, as do the local fish in the “Best Choices” table.
- **FISH FROM MANY OTHER WATER BODIES ARE KNOWN OR SUSPECTED TO HAVE ELEVATED MERCURY LEVELS**. Not all water bodies in California have been tested. It is recommended that fish from places without an advisory be eaten sparingly.

SAFE EATING GUIDELINES
FISH CONSUMPTION AT PUTAH CREEK

Fish are nutritious and should be part of a healthy, balanced diet. It is important, however, to choose your fish wisely. OEHHA recommends that you choose fish to eat that are low in mercury, including the following fish caught from Putah Creek.

BEST CHOICES (Up to 3 times a week)
Women of childbearing age and children 17 years and younger:
Trout or Sacramento blackfish
Women beyond childbearing age and men:
Trout*, Sacramento blackfish*, bluegill or other sunfish, catfish (including bullheads), sucker, carp or goldfish, or crayfish

* May be eaten daily by women beyond childbearing age and men

Because some other types of fish from Putah Creek contain higher levels of mercury, OEHHA provides the following recommendations that you can follow to reduce the risks from exposure to methylmercury in fish.

EAT SPARINGLY (No more than one meal a week)
Women of childbearing age and children 17 years and younger:
Black bass, bluegill or other sunfish, carp or goldfish, catfish (including bullheads), crappie, sucker, hitch, or crayfish
Women beyond childbearing age and men:
Black bass, crappie, or hitch

- **CONTACT WITH THE WATER IS SAFE.**
- **EAT SMALLER FISH OF LEGAL SIZE**. Fish accumulate mercury as they grow.
- **SERVE SMALLER MEALS TO CHILDREN**. Meal size is assumed to be 8 ounces for a 160-pound adult. If you weigh more or less than 160 pounds, add or subtract one ounce to your meal size, respectively, for each 20-pound difference in body weight.
- **DO NOT COMBINE FISH CONSUMPTION ADVICE**. If you eat multiple species or catch fish from more than one area, the recommended guidelines for different species and locations should not be combined.
- **CONSIDER YOUR TOTAL FISH CONSUMPTION**. Fish from many sources (including stores and restaurants) can contain elevated levels of mercury and other contaminants. If you eat commercial and/or sport fish with lower contaminant levels, you can safely eat more fish. The American Heart Association recommends that healthy adults eat at least two servings of fish per week. Commercial fish such as shrimp, king crab, scallops, farmed catfish, wild ocean salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest levels of mercury, as do the local fish in the “Best Choices” table.
- **FISH FROM MANY OTHER WATER BODIES ARE KNOWN OR SUSPECTED TO HAVE ELEVATED MERCURY LEVELS**. Not all water bodies in California have been tested. It is recommended that fish from places without an advisory be eaten sparingly.

RECOMMENDATIONS FOR FURTHER SAMPLING

It is recommended that further fish sampling be done to more clearly elucidate mercury concentrations in fish from Lake Berryessa and Putah Creek. In particular, emphasis should be placed on collecting data for popular fish species that were not previously sampled or had low sample size. For example, kokanee salmon and Eagle Lake trout, which are popular sport fish and planted by DFG, were not sampled. Only a limited number of white crappie, black crappie, rainbow trout, brown trout, green sunfish, redear sunfish, hitch, and Sacramento pikeminnow were collected at Putah Creek, and few samples were available for bluegill, carp, and smallmouth bass from Lake Berryessa. In addition, no samples of white crappie, black crappie, brown trout, green sunfish, redear sunfish, hitch, or Sacramento pikeminnow were collected in Lake Berryessa. Finally, although chinook (king) salmon were collected from Lake Berryessa, all of these samples were collected more than 20 years ago. Sampling at least nine fish of each of these species, if present, especially those with no prior samples, would provide the scientific basis for developing safe eating guidelines for these species. Also, additional data collected for those sport fish species that may have lower concentrations of mercury (e.g., kokanee and trout) can also provide anglers with more options for choosing lower-mercury fish to eat from these water bodies. Furthermore, because no fish from Lake Berryessa have been sampled for organic chemicals, it is recommended that fatty fish species from Lake Berryessa be analyzed for pesticides and PCBs to determine whether these contaminants could be a potential threat to human health.

REFERENCES

Aberg, B.; Ekman, L.; Falk, R.; Greitz, U.; Persson, G.; Snihs, J-O. (1969). Metabolism of methyl mercury (^{203}Hg) compounds in man. Arch. Environ. Health. 19:478-485.

Adams, J.; Barone, S., Jr.; LaMantia, A.; Philen, R.; Rice, D.C.; Spear, L.; Susser, E. (2000). Workshop to identify critical windows of exposure for children's health: Neurobehavioral Work Group summary. Environ. Health Perspect. 108 (suppl. 3):535-544.

American Heart Association. (2005). Fish and Omega-3 Fatty Acids, AHA Recommendation. Available online at: www.americanheart.org/presenter.jhtml?identifier=4632

American Heart Association. (2002). AHA Statement, New guidelines focus on fish, fish oil, omega-3 fatty acids, November 18, 2002. Available online at: www.americanheart.org/presenter.jhtml?identifier=3006624.

Alliance of CA Tribes/Tiller. (2005). Information obtained online at: http://www.allianceofcatribes.org/auburn.htm, where the following credits were provided: Selected tribal climate, location, land status, government, history and cultural information has been included in the Profile as authorized for use in this web site by Tribal Data Resources via an agreement with Tiller Research, Inc. as follows: Use of data from has been authorized under licensing agreement with Veronica E. Tiller, Ph.D., Tiller Research, Inc., dated May 27, 1997. "Tiller's Guide to Indian Country - Economic Profiles of American Indian Reservations" - Copyright 1996 Library of Congress Catalog Card Number: 95-081326 ISBN 1-885931-01-8.

Andren, A.W.; Nriagu, J.O. (1979). The global cycle of mercury. In: Nriagu, J.O., ed. The biogeochemistry of mercury in the environment. Topics in environmental health, Vol. 3. Amsterdam: Elsevier/North-Holland Biomedical Press. p.1-21.

ATSDR (1999). Agency for Toxic Substances and Disease Registry. Toxicological profile for mercury (update). Prepared by Research Triangle Institute under contract no. 205-93-0606. Public Health Service, U.S. Department of Health and Human Services.

Ayers, S.M. Department of Environmental Science and Policy, U.C. Davis, Davis, California. Personal communication, March 9, 2005.

Bacher, D. (2002) Floating pen program at Lake Berryessa yields larger trout and salmon. http://www.fishsniffer.com/dbacher/040502berryessa.html. April 5, 2002.

Bakir, F.; Damluji, S.F.; Amin-Zaki, L.; Murtadha, M.; Khalidi, A.; Al-Rawi, N.Y.; Tikriti, S.; Dhahir, H.I.; Clarkson, T.W.; Smith, J.C.; Doherty, R.A. (1973). Methylmercury poisoning in Iraq. Science 181:230-241.

Berlin, M. (1986). Mercury. In: Friberg, L.; Nordberg, G.F.; Vouk, V.B.; eds. Handbook on the toxicology of metals. 2nd ed. Vol. II. Specific metals. New York, Elsevier p. 387-445.

Bloom, N.S. (1992). On the chemical form of mercury in edible fish and marine invertebrate tissue. Can. J. Fish. Aquat. Sci. 49(5):1010-1017.

Brodberg, R.K.; Klasing, S.A. (2003). Evaluation of potential health effects of eating fish from Black Butte Reservoir (Glenn and Tehama Counties): Guidelines for sport fish consumption. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.

Brodberg, R.K.; Pollock, G.A. (1999). Prevalence of Selected Target Chemical Contaminants in Sport Fish from Two California Lakes: Public Health Designed Screening Study. Final Project Report. EPA Assistance Agreement No. CX 825856-01-0. California Environmental Protection Agency. Office of Environmental Health Hazard Assessment. Sacramento, California. June 1999.

Cheruka, S.R.; Montgomery-Downs, H.E.; Farkas, S.L.; Thoman, E.B.; Lammi-Keefe, C.J. (2002). Higher maternal plasma docosahexaenoic acid during pregnancy is associated with more mature neonatal sleep-state patterning. American Journal of Clinical Nutrition 76:608-613.

CIFFI (2005). 2004 Lake Berryessa Plant: 1,000 Eagle Lake Trout Planted. California Inland Fisheries Foundation, Incorporated. December 1, 2004. Available online at: http://www.kokanee.org/2004_lake_berryessa_plant.htm

Clarkson, T.W.; Amin-Zaki, L.; Al-Tikriti. (1976). An outbreak of methyl mercury poisoning due to consumption of contaminated grain. Fed. Proc. 35:2395-2399.

Cohen, J.T., Bellinger, D.C., Conner, W.E., Shaywitz, B.A. (2005). A quantitative analysis of prenatal intake of n-3 polyunsaturated fatty acids and cognitive development. Am J Prev Med 29(4):366.e1-366.e12. (Accessed online.)

Cramer, J.C. (2001). Human Population within the Bioregion: A Demographic Portrait. IN: A Thinking Mammal's Guide to the Watershed. A.J. Boyer, J. Goggans, D. Leroy, D Robertson, R. Thayer, eds. Structure and design of the Putah and Cache website is copyright © 2001 University of California. Available online at: http://bioregion.ucdavis.edu/book/00_Entering/00_05_demography.html. Copyright © 2001 James C. Cramer.

Davidson, P.W.; Myers, G.J.; Cox, C.; Axtell, C.; Shamlaye, C.; Sloane-Reeves, J.; Cernichiari, E.; Needham, L.; Choi, A.; Wang, Y.; Berlin, M.; Clarkson, T.W. (1998). Effects of prenatal and postnatal methylmercury exposure from fish consumption on neurodevelopment. JAMA 280:701-707.

Davidson, P.W.; Myers, G.J.; Cox, C.; Shamlaye, C.F.; Marsh, D.O.; Tanner, M.A.; Berlin, M.; Sloane-Reeves, J.; Cernichiari, E.; Choisy, O.; Choi, A.; Clarkson, T.W. (1995). Longitudinal neurodevelopmental study of Seychellois children following in utero exposure to methylmercury from maternal fish ingestion: outcomes at 19 and 29 months. Neurotoxicology 16(4):677-688.

Daviglus, M.L.; Stamler, J.; Orencia, A.J.; Dyer, A.R.; Liu, K.; Greenland, P.; Walsh, M.K.; Morris, D.; Shekelle, R.B. (1997). Fish consumption and the 30-year risk of fatal myocardial infarction. N. Engl. J. Med. 336:1046-53.

Elhassani, S.B. (1982-83). The many faces of methylmercury poisoning. J. Toxicol. Clin. Toxicol. 19(8):875-906.

Gassel, M. (2001). Chemicals in Fish: Consumption of Fish and Shellfish in California and the United States. Pesticide and Environmental Toxicology Section. Office of Environmental Health Hazard Assessment. California Environmental Protection Agency. Oakland, CA.

Giedd, J.N.; Blumenthal, J.; Jeffries, N.O.; Castellanos, F.X.; Liu, H.; Zijdenbos, A.; Paus, T.; Evans, A.C.; Rapoport, J.L. (1999). Brain development during childhood and adolescence: A longitudinal MRI study. Nature Neuroscience 2(10):861-863.

Grandjean, P.; Budtz-Jorgensen, E.; White, R.F.; Weihe, P.; Debes, F.; Keiding, N. (1999). Methylmercury exposure biomarkers as indicators of neurotoxicity in children aged 7 years. Am. J. Epidemiol. 150(3):310-305.

Grandjean, P.; Weihe, P.; White, R.F.; Keiding, N.; Budtz-Jorgensen, K.; Murato, K.; Needham, L. (1998). Prenatal exposure to methylmercury in the Faroe Islands and neurobehavioral performance at age seven years. Response to workgroup questions for presentation on 18-20 Nov. 1998. In Scientific Issues Relevant to Assessment of Health Effects from Exposure to Methylmercury. Appendix II-B. Faroe Islands Studies. National Institute for Environmental Health Sciences. Available online at: http://ntp-server.niehs.nih.gov/Main_Pages/PUBS/MethMercWkshpRpt.html

Grandjean, P.; Weihe, P.; White, R.; Debes, F.; Arai, S.; Yokoyama, K.; Murata, N.; Sorensen, N.; Dahl, R.; Jorgensen, P. (1997). Cognitive deficit in 7-year-old children with prenatal exposure to methylmercury. Neurotoxicol. Teratol. 19:417-428.

Harada, M. (1978). Congenital Minamata Disease: Intrauterine methylmercury poisoning. Teratology. 18:285-288.

Harris, W.S.; Isley, W.L. (2001). Clinical trial evidence for the cardioprotective effects of omega-3 fatty acids. Curr. Atheroscler. Rep. 3(2):174-9.

IARC. (1993). IARC Monographs on the evaluation of carcinogenic risks to humans: Beryllium, cadmium, mercury, and exposures in the glass manufacturing industry. Vol. 58. World Health Organization, International Agency for Research on Cancer.

IRIS. (2001). Integrated Risk Information System. Online at: http://www.epa.gov/iris/subst/0073.htm. Methylmercury (MeHg) (CASRN 22967-92-6). Database maintained by the Office of Health and Environmental Assessment. U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office, Cincinnati, Ohio.

IRIS. (1995). Integrated Risk Information System. Online at: http://www.epa.gov/iris/subst/0073.htm. Methylmercury (MeHg) (CASRN 22967-92-6). Database maintained by the Office of Health and Environmental Assessment. U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office, Cincinnati, Ohio.

IRIS. (1993). Integrated Risk Information System. Online at: http://www.epa.gov/iris/rfd.htm. Background Document 1A. Database maintained by the Office of Health and Environmental Assessment. U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office, Cincinnati, Ohio.

Iso, H.; Rexrode, K.M.; Stampfer, M.J.; Manson, J.E.; Colditz, G.A.; Speizer, F.; Hennekens, C.H.; Willett, W.C. (2001). Intake of fish and omega-3 fatty acids and risk of stroke in women. J. Am. Med. Assoc. 285(3):304-12.

Kjellstrom, T.; Kennedy, P.; Wallis, S.; Stewart, A.; Friberg, L.; Lind, B.; Wutherspoon, T.; Mantell, C. (1989). Physical and mental development of children with prenatal exposure to mercury from fish. Stage II: Interviews and psychological tests at age 6. National Swedish Environmental Protection Board Report 3642. Solna, Sweden.

Kjellstrom, T.; Kennedy, P.; Wallis, S.; Mantell, C. (1986). Physical and mental development of children with prenatal exposure to mercury from fish. Stage I: Preliminary tests at age 4. National Swedish Environmental Protection Board Report 3080. Solna, Sweden.

Klasing, S.; Brodberg, R.K. (2003). Evaluation of Potential Health Effects of Eating Fish from Selected Water Bodies in the Northern Sierra Nevada Foothills (Nevada, Placer, and Yuba Counties): Guidelines For Sport Fish Consumption. Final Report. Pesticide and Environmental Toxicology Section. Office of Environmental Health Hazard Assessment. California Environmental Protection Agency. Sacramento, CA

Krehl, W.A. (1972). Mercury, the slippery metal. Nutr. Today November/December 90-102.

Lentz, B. (2005) California Kokes: Your golden state guide to the top ten kokanee salmon lakes for 2004. California Game and Fish Magazine. January 12, 2005. Available online at: (http://www.californiagameandfish.com/ca_aa050804a/index.html).

Lim, S.Y.; Suzuki, H. (2000). Intakes of dietary docosahexaenoic acid ethyl ester and egg phosphatidylcholine improve maze-learning ability in young and old mice. J. Nutr. 130(6):1629-32.

Lund, J.W. (2004). Historical impacts of geothermal resources on the people of North America. Available at http://geoheat.oit.edu/bulletin/bull16-4/art2.htm. Revision of paper published in the Proceedings of the 1995 World Geothermal Congress, Florence, Italy.

Marsh, D.O. (1987). Dose-response relationships in humans: Methyl mercury epidemics in Japan and Iraq. In: The Toxicity of Methyl Mercury. Eccles, C.U.; Annau, Z., eds. Baltimore, MD: John Hopkins University Press. p. 45-53.

Marsh, D.O.; Clarkson, T.W.; Cox, C.; Myers, G.J.; Amin-Zaki, L.; Al-Tikriti, S. (1987). Fetal methylmercury poisoning: Relationship between concentration in single strands of maternal hair and child effects. Arch. Neurol. 44:1017-1022.

Marsh, D.O.; Myers, G.J.; Clarkson, T.W.; Amin-Zaki, L.; Tikriti, S.; Majeed, M.A. (1980). Fetal methylmercury poisoning: Clinical and toxicological data on 29 cases. Ann. Neurol. 7:348-353.

Matsumoto, H.; Koya, G.; Takeuchi, T. (1964). Fetal Minamata Disease: A neuropathological study of two cases of intrauterine intoxication by a methyl mercury compound. J. Neuropathol. Exp. Neurol. 24:563-574.

Mishima, A. (1992). Bitter Sea: The Human Cost of Minamata Disease. Tokyo: Kosei Publishing Co. 231 p.

Mori, T.A.; Beilin, L.J. (2001). Long-chain omega 3 fatty acids, blood lipids and cardiovascular risk reduction. Curr. Opin. Lipidol. 12(1):11-7.

Moriguchi, T.; Greiner, R.S.; Salem, N. (2000). Behavioral deficits associated with dietary induction of decreased brain docosahexaenoic acid concentration. J. Neurochem. 75(6):2563-73.

Moyle, P.B. (2003). The Putah-Cache Bioregion Project: Putah Creek: Four Versions At UCD. Fall 2003. Available online at: http://wfcb.ucdavis.edu/www/Faculty/Peter/petermoyle/publications/filedtrips_00_putahcreek.pdf.

Moyle, P.B. (2002). Inland Fishes of California. Revised and Expanded. University of California Press.

Moyle, P.B. (2001a). The Fishes of Putah Creek: After the Dam. IN: A Thinking Mammal's Guide to the Watershed. A.J. Boyer, J. Goggans, D. Leroy, D Robertson, R. Thayer, eds. Structure and design of the Putah and Cache website is copyright © 2001 University of California. Available online at: http://bioregion.ucdavis.edu/book/04_Lake_Solano/04_04_moyle_fish_lowpc.html. copyright © 2001 Peter B. Moyle.

Moyle, P.B. (2001b). The Fishes of Putah Creek: Lower Putah Creek. IN: A Thinking Mammal's Guide to the Watershed. A.J. Boyer, J. Goggans, D. Leroy, D Robertson, R. Thayer, eds. Structure and design of the Putah and Cache website is copyright © 2001 University of California. Available online at: http://bioregion.ucdavis.edu/book/04_Lake_Solano/04_04_moyle_fish_lowpc.html. copyright © 2001 Peter B. Moyle.

Myers, G.J.; Davidson, P.W.; Palumbo, D.; Shamlaye, C.; Cox, C.; Cernichiari, E.; Clarkson, T.W. (2000). Secondary analysis from the Seychelles Child Development Study: The child behavior checklist. Environ. Research. Section A 84:12-19.

NRC/NAS. (2000). Toxicological effects of methylmercury. Report of the National Research Council, Committee on the toxicological effects of methylmercury. Washington DC: National Academy Press.

OEHHA. (2004). *Final Berryessa_Putah data used for advisory_March 2005.xls*. Electronic database amended from the Central Valley Regional Water Quality Control Board electronic database, received February 25, 2003.

Oken, E.; Wright, R.O.; Kleinman, K.P.; Bellinger, D.; Amarasiriwardena, C.J.; Hu, H.; Rich-Edwards, J.W.; Gillman, M.W. (2005). Maternal fish consumption, hair mercury, and infant cognition in a U.S. cohort. Environ. Health Perspect. 113(10):1376-1380.

Paus, T.; Zijdenbos, A.; Worsley, K.; Collins, D.L.; Blumenthal, J.; Giedd, J.N.; Rapoport, J.L.; Evans, A.C. (1999). Structural maturation of neural pathways in children and adolescents: In vivo study. Science 283:1908-1911.

Rice, D.; Barone, S., Jr. (2000). Critical periods of vulnerability for the developing nervous system: Evidence from humans and animal models. Environ. Health Perspect. 108 (suppl. 3):511-33.

Sak, B. (2005). North State Bass Outlook. California Game and Fish Magazine. January 12, 2005. Available online at: http://www.californiagameandfish.com/ca_aa040803a/index.html

Seafood Safety. (1991). Committee on Evaluation of the Safety of Fishery Products, Chapter on Methylmercury: FDA Risk Assessment and Current Regulations, National Academy Press, Washington, DC. p.196-221.

Slotton, D.G. (2005). Department of Environmental Science and Policy, U.C. Davis, Davis, California. Electronic communication (e-mail) to M. Gassel on February 25, 2005).

Slotton, D.G., Ayers, S.M., Suchanek, T.H., Weyland, R.D., Liston, A.M. (2004). Mercury Bioaccumulation and Trophic Transfer in the Cache Creek Watershed of California, in Relation to Diverse Aqueous Mercury Exposure Conditions. Final Report. Janurary 25, 2004. Task 5B of a CALFED Bay-Delta Program Project, Assessment of Ecological and Human Health Impacts of Mercury in the San Francisco Bay-Delta Watershed.

Smith, J.C.; Allen, P.V.; Turner, M.D.; Most, B.; Fisher, H.L.; Hall, L.L. (1994). The kinetics of intravenously administered methyl mercury in man. Toxicol. Appl. Pharmacol. 128(2):251-256.

Snyder, R.D. (1971). Congenital mercury poisoning. New Engl. J. Med. 218:1014-1016.

Stopford, W.; Goldwater, L.J. (1975). Methylmercury in the environment: A review of current understanding. Environ. Health Perspect. 12:115-118.

Stratton, J.W.; Smith, D.F.; Fan, A.M.; Book, S.A. (1987). Methyl Mercury in Northern Coastal Mountain Lakes: Guidelines for Sport Fish Consumption for Clear Lake (Lake County), Lake

Berryessa (Napa County), and Lake Herman (Solano County). Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.

Thayer, R. (2001). The Monticello Dam Overlook. IN: Putah and Cache: A Thinking Mammal's Guide to the Watershed. A.J. Boyer, J. Goggans, D. Leroy, D. Robertson, R. Thayer, eds. Available online at: http://bioregion.ucdavis.edu/book/06_Monticello_Dam/06_01_circ_montdam.html.

Tollefson, L.; Cordle, F. (1986). Methyl mercury in fish: A review of residue levels, fish consumption and regulatory action in the United States. Environ. Health Perspect. 68:203-208.

U.S. Bureau of Mines. (1965). Mercury potential of the United States, by Bureau of Mines Staff. Washington. U.S. Dept. of the Interior, Bureau of Mines.

U.S. EPA. (2004). Joint Federal Advisory for Mercury in Fish. What You Need to Know about Mercury in Fish and Shellfish. Available online at: http://www.epa.gov/waterscience/fishadvice/advice.html

U.S. EPA (2000a). Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Vol. 1. Fish Sampling and Analysis. Third Edition. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA (2000b). Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Vol. 2. Risk Assessment and Fish Consumption Limits. Third Edition. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. (1997). Mercury Study Report to Congress. Volume VII: Characterization of Human Health and Wildlife Risks from Mercury Exposure in the United States. EPA-452/R-97-009. U.S. Environmental Protection Agency, Office of Air Quality Planning & Standards and Office of Research and Development, Washington, DC.

USGS. (1997). U.S. Geological Survey Programs inCalifornia: Sources of Mercury. U.S. Department of the Interior. U.S. Geological Survey. Available online at: http://water.usgs.gov/pubs/fs/FS-005-96/#HDR13.

Valagussa, F.; Fronzosi, M.G.; Geraci, E. *et al.* (1999). Dietary supplementation with n-3 fatty acids and vitamin E after myocardial infarction: results of the GISSI-Prevenzione trial. Lancet 354(9177):447-55.

von Schacky, C.; Angerer, P.; Kothny, W.; Theisen, K.; Mudra, H. (1999). The effect of dietary omega-3 fatty acids on coronary atherosclerosis. A randomized, double-blind, placebo-controlled trial. Ann. Intern. Med. 130(7):554-62.

WHO (World Health Organization). (1990). Methylmercury. Environmental Health Criteria 101. Geneva: World Health Organization.

WHO (World Health Organization). (1989). Mercury – Environmental Aspects. Environmental Health Criteria 86. Geneva: World Health Organization.

WHO (World Health Organization). (1976). Environmental Health Criteria. Mercury. Geneva, Switzerland: World Health Organization.

Table 1. Summary Statistics for Legal and/or Edible-size Fish from Lake Berryessa

Species	Mean* Mercury (ppm)	Mean Total Length (mm TL)	Number of Samples (Total Number of Fish)	Minimum Acceptable Size (mm TL)
Channel Catfish	**0.52**	300	119 (119)	200
White Catfish	**0.77**	242	23 (23)	200
Catfish	**0.56**	291	142 (142)	200
Largemouth Bass	**0.75**	367	32 (32)	305
Smallmouth Bass	0.93	357	1 (1)	305
Black bass	**0.76**	367	33 (33)	305
Rainbow trout	**0.17**	342	29 (29)	200
Chinook (king) Salmon	**0.48**	489	11 (11)	[1]
Bluegill	0.39	182	2 (3)	100
Carp	0.54	558	2 (2)	200

Values in **BOLD** indicate results from samples with sufficient numbers
TL = total length

[1] No minimum legal size for inland salmon; smallest sample was 340 mm.

Table 2. Summary Statistics for Legal and/or Edible-size Fish and Shellfish from Putah Creek

Species	Mean Mercury (ppm)	Mean Total Length[1] (mm)	Number of Samples (Total Number of Fish)	Minimum Acceptable Size (mm TL)
Channel Catfish	**0.15**	461	13 (13)	200
White Catfish	**0.14**	407	9 (9)	200
Catfish	**0.14**	407	9 (9)	200
Largemouth Bass	**0.46**	374	23 (34)	305
Sacramento Blackfish	**0.09**	377	20 (20)	200
Sacramento Sucker[2]	**0.16**	393	12 (20)	200
Bluegill	**0.14**	142	18 (42)	100
Green Sunfish	0.17	113	2 (2)	100
Redear Sunfish	0.15	202	1 (1)	130
Hybrid Sunfish	0.19	187	1 (1)	NA[3]
Sunfish	**0.14**	143	22 (46)	100
Carp	**0.18**	480	15 (15)	200
Rainbow Trout	0.08	307	6 (6)	200
Brown Trout	0.06	301	1 (5)	200
Trout	**0.07**	304	7 (11)	200
White Crappie	0.28	227	4 (4)	150
Black Crappie	0.33	198	1 (1)	150
Crappie	0.29	221	5 (5)	150
Hitch	0.09	317	5 (5)	150 TL
Sacramento Pikeminnow	0.50	341	5 (5)	250 TL
Crayfish[4]	**0.21**	47	56 (56)	NA[5]

Values in **BOLD** indicate results from samples with sufficient numbers
TL = total length

[1] Fish are reported in total length; crayfish are reported in carapace length.

[2] Includes one sample of four fish labeled only as "sucker (*Catostomus sp.*)"

[3] NA: Because this was a hybrid, a conversion factor was not developed; the one sample was sufficient in length.

[4] Includes red swamp crayfish, signal crayfish, and northern crayfish

[5] NA: Crayfish of all sizes were used; all samples were considered edible size (S. Ayers, pers. comm.)

Table 3: Guidance Tissue Levels (ppm Total Mercury or Methylmercury*, wet weight) for Two Population Groups

Population group:	***Women of child-bearing age and children aged 17 years and younger***	***Women beyond childbearing age and men***
Reference Dose (RfD):	*1 x 10^{-4} mg/kg/day*	*3 x 10^{-4} mg/kg/day*
Meals per Month	***Tissue concentration (ppm)***	
30	< 0.03	< 0.09
12	< 0.08	< 0.23
8	< 0.12	< 0.35
7	< 0.14	< 0.41
6	< 0.16	< 0.47
5	< 0.20	< 0.58
4	< 0.23	< 0.70
3	< 0.35	< 1.05
2	< 0.47	< 1.40
1	< 0.93	< 2.80
0	≥ 0.93	≥ 2.80

Legend: The numbers of meals per month are designated in the following categories:

Best Choices Eat Sparingly Avoid

*The values in this table are based on the assumption that 100% of total mercury measured in fish is methylmercury. This may not be true for shellfish, so methylmercury needs to be measured directly in these species for use in this table.

The recommended level for consumption of fish contaminated with a non-carcinogenic chemical such as methylmercury is below or equivalent to the chemical's reference level. People could eat more fish with a lower tissue concentration (before they exceed the reference level) than fish with a higher concentration. The following general equation can be used to calculate the fish tissue concentration (in mg/kg) at which the consumption exposure from a chemical with a non-carcinogenic effect is equal to the reference level for that chemical at any consumption level:

$$\text{Tissue concentration} = \frac{(\text{RfD mg/kg - day})(\text{kg Body Weight})(\text{RSC})}{\text{CR kg/day}}$$

where,

RfD = Chemical specific reference dose or other reference level
BW = Body weight of consumer
RSC = Relative source contribution of fish to total exposure
CR = Consumption rate as the daily amount of fish consumed

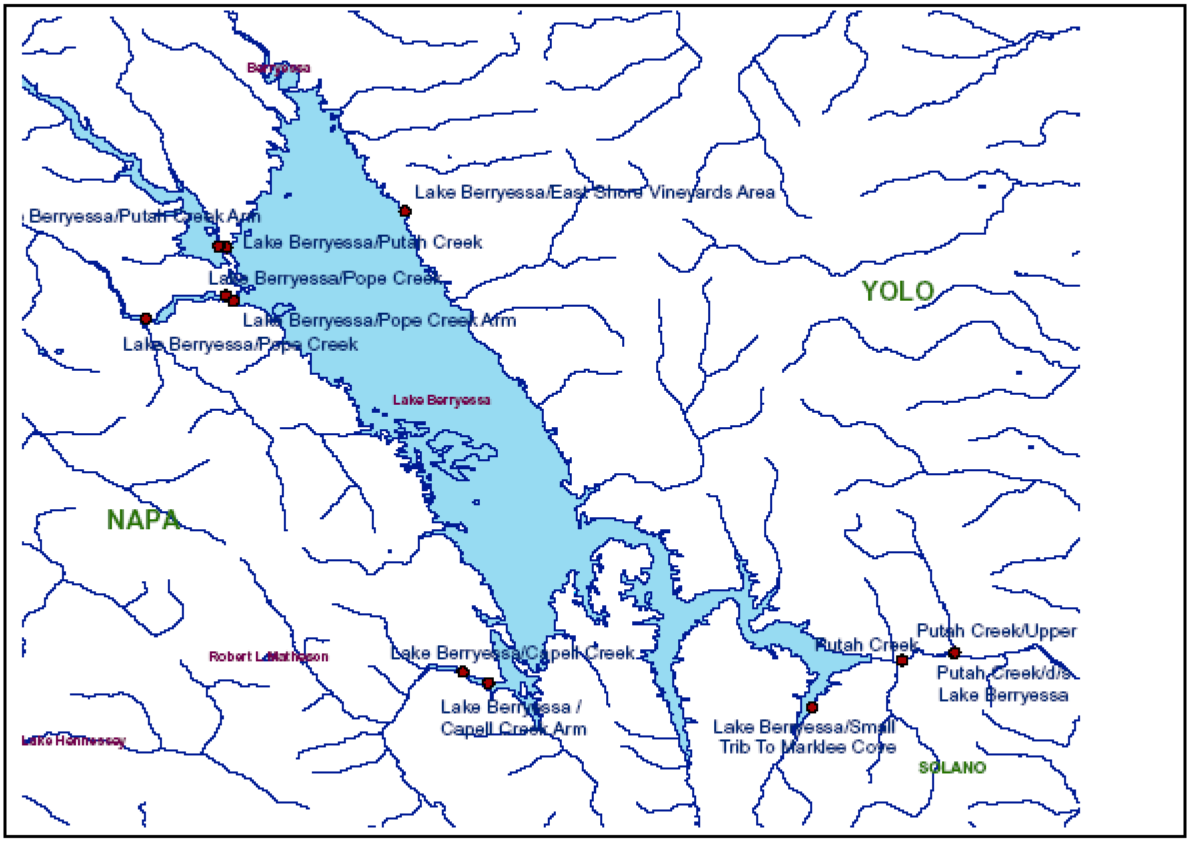
For example: $\frac{(1 \times 10^{-4}\ \text{mg/kg-day})(70\ \text{kg body weight})\ (1)}{.030\ \text{kg/day}} = 0.23$ mg/kg tissue

When the tissue concentration of the chemical is known (*i.e.*, after sampling and analyzing sufficient numbers of fish in a population at a water body), one can enter that value in the equation and solve for the recommended meal frequency that would result in exposure being equivalent to the reference dose. Alternatively, one can look up the associated meal frequency in the GTL table. The GTL table is color-coded to indicate which meal frequencies correspond to the consumption levels provided in the safe eating guidelines. For example, fish tissues with mercury concentrations greater than 0.47 ppm and less than 0.93 ppm could be eaten once a month by women of childbearing age and children at an exposure level equal to the reference dose. Similarly, women of childbearing age and children are advised not to eat fish with mercury concentrations greater than 0.93 ppm. Both of these consumption categories (one meal a month and no consumption) are included under “Avoid” because, in both cases, it is best to avoid consumption of species with mercury concentrations this high, and eat fish that are lower in mercury as an alternative in order to enjoy the benefits of fish consumption without excessive exposure to methylmercury.

This equation was applied above to determine tissue concentrations of methylmercury (assuming 100% of measured total mercury is methylmercury in fish) in sport fish that would be below or equivalent to the chemical's reference level when eating different amounts of fish. An RfD of $1\text{x}10^{-4}$ mg/kg-day was used for women of childbearing age and children aged 17 years and younger. An RfD of $3\text{x}10^{-4}$ mg/kg-day was used for women beyond their childbearing years and men. A body weight of 70 kg was used to represent the average weight of an adult. It was assumed that fish represent 100 percent of the source of methylmercury to a fish consumer.

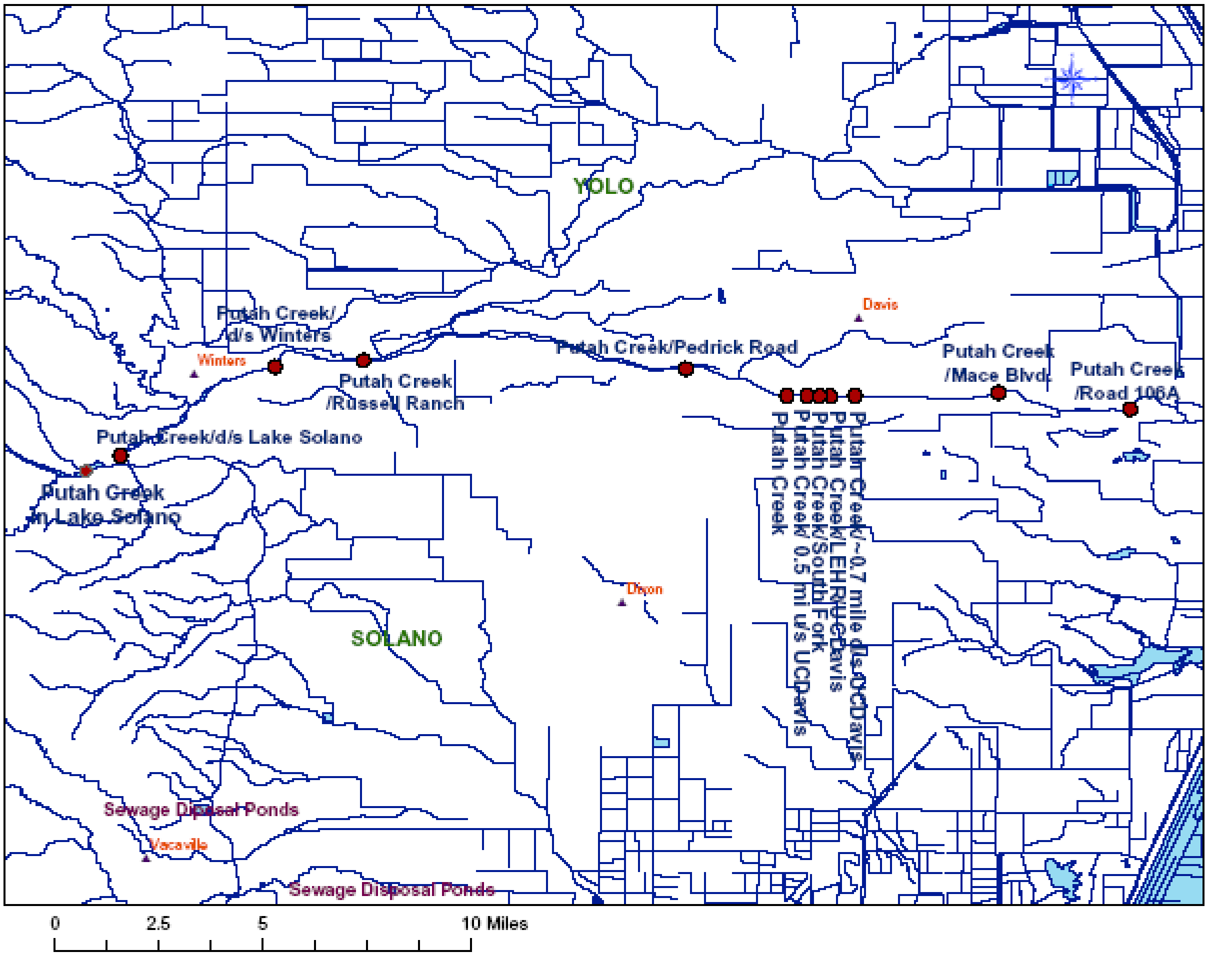
Meal Sizes used in this table: Although people eat different meal sizes, their typical portion size is related to their individual body weight in a fairly consistent manner. The standard portion size eaten by an average adult (body weight 70 kg or 154 pounds) is eight ounces (227 g) (U.S. EPA, 1994). People tend to remember how many meals of a specific food they eat in a month and this interval is often used in consumption surveys (Gassel, 2001). A standard portion of one fish meal a month is equivalent to $7.5\ \text{x}10^{-3}$ kg/day, one meal per week is equivalent to $3.0\ \text{x}10^{-2}$ kg/day, and three meals per week is equivalent to $9.0\ \text{x}10^{-2}$ kg/day.

Figure 1. Map of Lake Berryessa with Sampling Sites



Sampling sites indicated by circles

Figure 2. Map of Sampling Sites on Putah Creek



Sampling sites indicated by circles

Figure 3. Scatterplot for Comparison of Channel Catfish From Lake Berryessa and Putah Creek

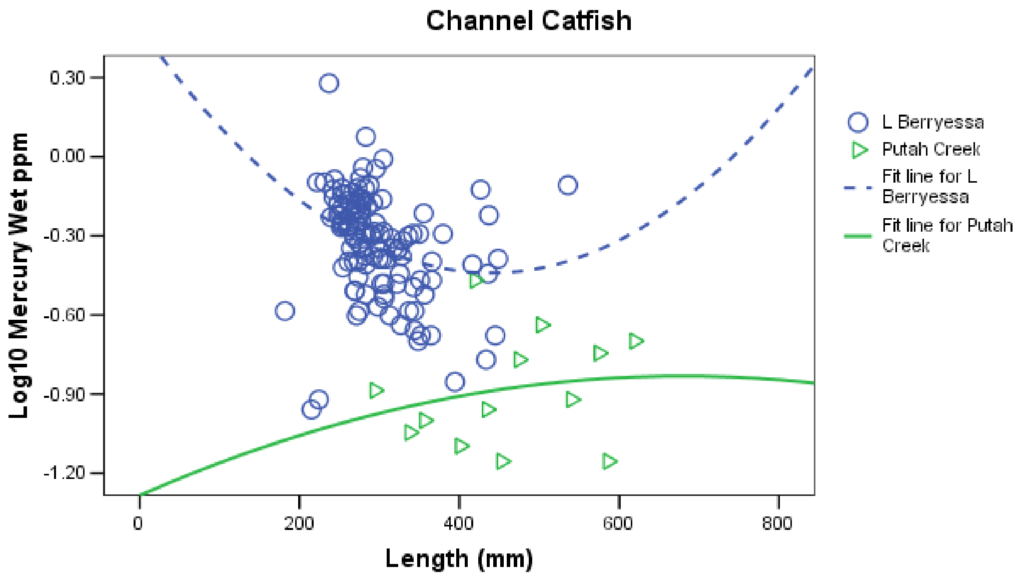
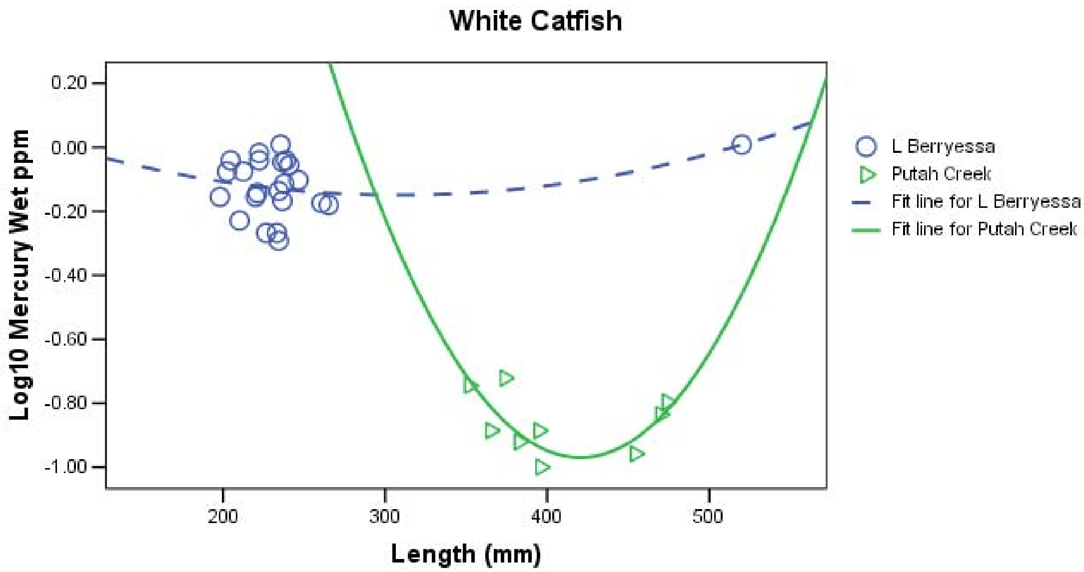


Figure 4. Scatterplot for Comparison of White Catfish From Lake Berryessa and Putah Creek



Appendix I: 1987 Advisory for Lake Berryessa

RECOMMENDED FISH CONSUMPTION GUIDELINES FOR SPORT FISH

Because of mercury levels in fish, women who are pregnant or who may soon become pregnant, nursing mothers, and children under age 6 should not eat fish from the lakes listed below. Adults should eat no more than the amount indicated below. Children 6-15 years of age should eat no more than one-half the amount indicated.

Lake Berryessa (Napa County)

Largemouth bass over 15 inches: 1 pound per month

or largemouth bass under 15 inches: 2 pounds per month

or all smallmouth bass: 1 pound per month

or all channel catfish: 3 pounds per month

or all white catfish: 2 pounds per month

or all rainbow trout: 10 pounds per month

Appendix II: Methylmercury in Sport Fish: Information for Fish Consumers

Methylmercury is a form of mercury that is found in most freshwater and saltwater fish. In some lakes, rivers, and coastal waters in California, methylmercury has been found in some types of fish at concentrations that may be harmful to human health. The Office of Environmental Health Hazard Assessment (OEHHA) has issued health advisories to fishers and their families giving recommendations on how much of the affected fish in these areas can be safely eaten. In these advisories, women of childbearing age and children are encouraged to be especially careful about following the advice because of the greater sensitivity of fetuses and children to methylmercury.

Fish are nutritious and should be a part of a healthy, balanced diet. As with many other kinds of food, however, it is prudent to consume fish in moderation. OEHHA provides advice to the public so that people can continue to eat fish without putting their health at risk.

WHERE DOES METHYLMERCURY IN FISH COME FROM?

Methylmercury in fish comes from mercury in the aquatic environment. Mercury, a metal, is widely found in nature in rock and soil, and is washed into surface waters during storms. Mercury evaporates from rock, soil, and water into the air, and then falls back to the earth in rain, often far from where it started. Human activities redistribute mercury and can increase its concentration in the aquatic environment. The coastal mountains in northern California are naturally rich in mercury in the form of cinnabar ore, which was processed to produce quicksilver, a liquid form of inorganic mercury. This mercury was taken to the Sierra Nevada, Klamath mountains, and other regions, where it was used in gold mining. Historic mining operations and the remaining tailings from abandoned mercury and gold mines have contributed to the release of large amounts of mercury into California's surface waters. Mercury can also be released into the environment from industrial sources, including the burning of fossil fuels and solid wastes, and disposal of mercury-containing products.

Once mercury gets into water, much of it settles to the bottom where bacteria in the mud or sand convert it to the organic form of methylmercury. Fish absorb methylmercury when they eat smaller aquatic organisms. Larger and older fish absorb more methylmercury as they eat other fish. In this way, the amount of methylmercury builds up as it passes through the food chain. Fish eliminate methylmercury slowly, and so it builds up in fish in much greater concentrations than in the surrounding water. Methylmercury generally reaches the highest levels in predatory fish at the top of the aquatic food chain.

HOW MIGHT I BE EXPOSED TO METHYLMERCURY?

Eating fish is the main way that people are exposed to methylmercury. Each person's exposure depends on the amount of methylmercury in the fish that they eat and how much and how often they eat fish.

Women can pass methylmercury to their babies during pregnancy, and this includes methylmercury that has built up in the mother's body even before pregnancy. For this reason, women of childbearing age are encouraged to be especially careful to follow consumption advice, even if they are not pregnant. In addition, nursing mothers can pass methylmercury to their child through breast milk.

You may be exposed to inorganic forms of mercury through dental amalgams (fillings) or accidental spills, such as from a broken thermometer. For most people, these sources of exposure to mercury are minor and of less concern than exposure to methylmercury in fish.

AT WHAT LOCATIONS IN CALIFORNIA HAVE ELEVATED LEVELS OF MERCURY BEEN FOUND IN FISH?

Methylmercury is found in most fish, but some fish and some locations have higher amounts than others. Methylmercury is one of the chemicals in fish that most often creates a health concern. Consumption advisories due to high levels of methylmercury in fish have been issued in about 40 states. In California, methylmercury advisories have been issued for San Francisco Bay and the Delta; Tomales Bay in Marin County; and at the following inland lakes: Lake Nacimiento in San Luis Obispo County; Lake Pillsbury and Clear Lake in Lake County; Lake Berryessa in Napa County; Guadalupe Reservoir and associated reservoirs in Santa Clara County; Lake Herman in Solano County; San Pablo Reservoir in Contra Costa County; Black Butte Reservoir in Glenn and Tehama Counties; Lake Natoma and the lower American River in Sacramento County; Trinity Lake in Trinity County; and certain lakes and river stretches in the Sierra Nevada foothills in Nevada, Placer, and Yuba counties. Other locations may be added in the future as more fish and additional water bodies are tested.

HOW DOES METHYLMERCURY AFFECT HEALTH?

Much of what we know about methylmercury toxicity in humans stems from several mass poisoning events that occurred in Japan during the 1950s and 1960s, and Iraq during the 1970s. In Japan, a chemical factory discharged vast quantities of mercury into several bays near fishing villages. Many people who consumed large amounts of fish from these bays became seriously ill or died over a period of several years. In Iraq, thousands of people were poisoned by eating contaminated bread that was mistakenly made from seed grain treated with methylmercury.

From studying these cases, researchers have determined that the main target of methylmercury toxicity is the central nervous system. At the highest exposure levels experienced in these poisonings, methylmercury toxicity symptoms included such nervous system effects as loss of coordination, blurred vision or blindness, and hearing and speech impairment. Scientists also discovered that the developing nervous systems of fetuses are particularly sensitive to the toxic effects of methylmercury. In the Japanese outbreak, for example, some fetuses developed methylmercury toxicity during pregnancy even when their mothers did not. Symptoms reported in the Japan and Iraq epidemics resulted from methylmercury levels that were much higher than what fish consumers in the U.S. would experience.

Individual cases of adverse health effects from heavy consumption of commercial fish containing moderate to high levels of methylmercury have been reported only rarely. Nervous system symptoms reported in these instances included headaches, fatigue, blurred vision, tremor, and/or some loss of concentration, coordination, or memory. However, because there was no clear link between the severity of symptoms and the amount of mercury to which the person was exposed, it is not possible to say with certainly that these effects were a consequence of methylmercury exposure and not the result of other health problems. The most subtle symptoms in adults known to be clearly associated with methylmercury toxicity are numbness or tingling in the hands and feet or around the mouth; however, these symptoms are also associated with other medical conditions not related to methylmercury exposure.

In recent studies of high fish-eating populations in different parts of the world, researchers have been able to detect more subtle effects of methylmercury toxicity in children whose mothers frequently ate seafood containing low to moderate mercury concentrations during their pregnancy. Several studies found slight decreases in learning ability, language skills, attention and/or memory in some of these children. These effects were not obvious without using very specialized and sensitive tests. Children may have increased susceptibility to the effects of methylmercury through adolescence, as the nervous system continues to develop during this time.

Methylmercury builds up in the body if exposure continues to occur over time. Exposure to relatively high doses of methylmercury for a long period of time may also cause problems in other organs such as the kidneys and heart.

CAN MERCURY POISONING OCCUR FROM EATING SPORT FISH IN CALIFORNIA?

No case of mercury poisoning has been reported from eating California sport fish. The levels of mercury in California fish are much lower than those that occurred during the Japanese outbreak. Therefore, overt poisoning resulting from sport fish consumption in California would not be expected. At the levels of mercury found in California fish, symptoms associated with methylmercury are unlikely unless someone eats much more than what is recommended or is particularly sensitive. The fish consumption guidelines are designed to protect against subtle effects that would be difficult to detect but could still occur following unrestricted consumption of California sport fish. This is especially true in the case of fetuses and children.

IS THERE A WAY TO REDUCE METHYLMERCURY IN FISH TO MAKE THEM SAFER TO EAT?

There is no specific method of cleaning or cooking fish that will significantly reduce the amount of methylmercury in the fish. However, fish should be cleaned and gutted before cooking because some mercury may be present in the liver and other organs of the fish. These organs should not be eaten.

In the case of methylmercury, fish size is important because large fish that prey upon smaller fish can accumulate more of the chemical in their bodies. It is better to eat the smaller fish within the same species, provided that they are legal size.

IS THERE A MEDICAL TEST TO DETERMINE EXPOSURE TO METHYLMERCURY?

Mercury in blood and hair can be measured to assess methylmercury exposure. However, this is not routinely done. Special techniques in sample collection, preparation, and analysis are required for these tests to be accurate. Although tests using hair are less invasive, they are also less accurate. It is important to consult with a physician before undertaking medical testing because these tests alone cannot determine the cause of personal symptoms.

HOW CAN I REDUCE THE AMOUNT OF METHYLMERCURY IN MY BODY?

Methylmercury is eliminated from the body over time provided that the amount of mercury taken in is reduced. Therefore, following the OEHHA consumption advice and eating less of the fish that have higher levels of mercury can reduce your exposure and help to decrease the levels of methylmercury already in your body if you have not followed these recommendations in the past.

WHAT IF I EAT FISH FROM OTHER SOURCES SUCH AS RESTAURANTS, STORES, OR OTHER WATER BODIES THAT MAY NOT HAVE AN ADVISORY?

Most commercial fish have relatively low amounts of methylmercury and can be eaten safely in moderate amounts. However, several types of fish such as large, predatory, long-lived fish have high levels of methylmercury, and could cause overly high exposure to methylmercury if eaten often. The U.S. Food and Drug Administration (FDA) is responsible for the safety of commercial seafood. In 2004, FDA and the U.S. Environmental Protection Agency (U.S. EPA) issued a Joint Federal Advisory for Mercury in Fish advising women who are pregnant or could become pregnant, nursing mothers, and young children not to eat shark, swordfish, king mackerel, or tilefish. The federal advisory also recommends that these individuals can safely eat up to an average of 12 ounces (two average meals) per week of a variety of other cooked fish purchased in stores or restaurants, such as shrimp, canned light tuna, salmon, pollock, or (farm-raised) catfish. Albacore ("white") tuna is known to contain more mercury than canned light tuna; it is therefore recommended that no more than six ounces of albacore tuna be consumed per week. In addition, the federal advisory recommends that women who are pregnant or may become pregnant, nursing mothers, and young children consume no more than one meal per week of locally caught fish, when no other advice is available, and eat no other fish that week. The federal advisory can be found at http://www.cfsan.fda.gov/~dms/admehg.html or http://www.epa.gov/ost/fishadvice/advice.html.

In addition, OEHHA offers the following general advice that can be followed to reduce exposure to methylmercury in fish. Chemical levels can vary from place to place. Therefore, your overall exposure to chemicals is likely to be lower if you fish at a variety of places, rather than at one location that might have high contamination levels. Furthermore, some fish species have higher chemical levels than others in the same location. If possible, eat smaller amounts of several different types of fish rather than a large amount of one type that may be high in contaminants. Smaller fish of a species will usually have lower chemical levels than larger fish in the same location because some of the chemicals may become more concentrated in larger, older fish. It is advisable to eat smaller fish (of legal size) more often than larger fish. Cleaning and cooking fish in a manner that removes fat and organs is an effective way to reduce other contaminants that may be present in fish.

WHERE CAN I GET MORE INFORMATION?

The health advisories for sport fish are printed in the California Sport Fishing Regulations booklet, which is available wherever fishing licenses are sold. OEHHA also offers a booklet containing the advisories, and additional materials such as this fact sheet on related topics. Additional information and documents related to fish advisories are available on the OEHHA Web Site at http://www.oehha.ca.gov/fish.html. County departments of environmental health may have more information on specific fishing areas.

Appendix III. General Advice for Sport Fish Consumption

You can reduce your exposure to chemical contaminants in sport fish by following the recommendations below. Follow as many of them as you can to increase your health protection. This general advice is not meant to take the place of advisories for specific areas, but should be followed in addition to them. Sport fish in most water bodies in the state have not been evaluated for their safety for human consumption. This is why we strongly recommend following the general advice given below.

Fishing Practices

Chemical levels can vary from place to place. Your overall exposure to chemicals is likely to be lower if you eat fish from a variety of places rather than from one usual spot that might have high contamination levels.

Be aware that OEHHA may issue new advisories or revise existing ones. Consult the Department of Fish and Game regulations booklet or check with OEHHA on a regular basis to see if there are any changes that could affect you.

Consumption Guidelines

Fish Species: Some fish species have higher chemical levels than others in the same location. If possible, eat smaller amounts of several different types of fish rather than a large amount of one type that may be high in contaminants.

Fish Size: Smaller fish of a species will usually have lower chemical levels than larger fish in the same location because some of the chemicals may accumulate as the fish grows. It is advisable to eat smaller fish (of legal size).

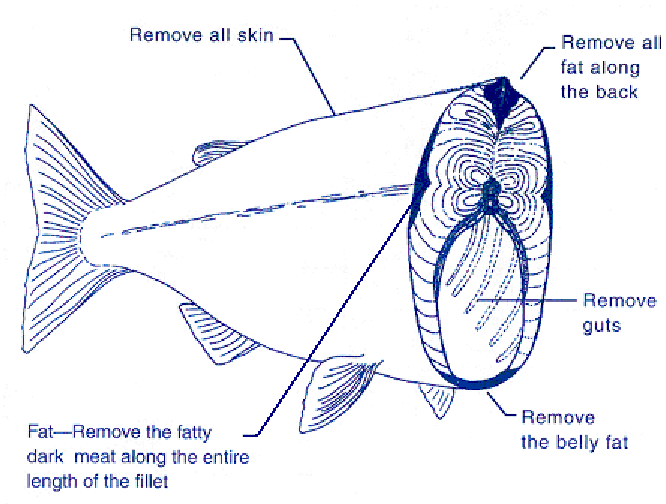
Fish Preparation and Consumption

• Eat only the fillet portions. Do not eat the guts and liver because chemicals usually concentrate in those parts. Also, avoid frequent consumption of any reproductive parts such as eggs or roe.

• Many chemicals are stored in the fat. To reduce the levels of these chemicals, skin the fish when possible and trim any visible fat.

• Use a cooking method such as baking, broiling, grilling, or steaming that allows the juices to drain away from the fish. The juices will contain chemicals in the fat and should be thrown away. Preparing and cooking fish in this way can remove 30 to 50 percent of the chemicals stored in fat. If you make stews or chowders, use fillet parts.

• Raw fish may be infested by parasites. Cook fish thoroughly to destroy the parasites.



Advice For Pregnant Women, Women of Childbearing Age, and Children

Children and fetuses are more sensitive to the toxic effects of methylmercury, the form of mercury of health concern in fish. For this reason, OEHHA's advisories that are based on mercury provide special advice for women of childbearing age and children. Women should follow this advice throughout their childbearing years.

The U.S. Food and Drug Administration (FDA) is responsible for the safety of commercial seafood. Most commercial fish have relatively low amounts of methylmercury and can be eaten safely in moderate amounts. However, several types of fish such as large, predatory, long-lived fish have high levels of methylmercury, and could cause overly high exposure to methylmercury if eaten often. In 2004, FDA and the U.S. Environmental Protection Agency (U.S. EPA) issued a Joint Federal Advisory for Mercury in Fish advising women who are pregnant or could become pregnant, nursing mothers, and young children not to eat shark, swordfish, king mackerel, or tilefish. The federal advisory also recommends that these individuals can safely eat up to an average of 12 ounces (two average meals) per week of a variety of other cooked fish purchased in stores or restaurants, such as shrimp, canned light tuna, salmon, pollock, or (farm-raised) catfish. Albacore ("white") tuna is known to contain more mercury than canned light tuna; it is therefore recommended that no more than six ounces of albacore tuna be consumed per week. In addition, the federal advisory recommends that women who are pregnant or may become pregnant, nursing mothers, and young children consume no more than one meal per week of locally caught fish, when no other advice is available, and eat no other fish that week. The federal advisory can be found at http://www.cfsan.fda.gov/~dms/admehg.html or http://www.epa.gov/ost/fishadvice/advice.html.

Appendix IV. Corrections to Lake Berryessa and Putah Creek Data Entries

2003Feb25_RegBrd5-FishHgData file from Michelle Wood, CVRWQCB

1. SRWP2: We deleted two 'SRWP2' duplicate bluegill samples (Putah Creek Year 2000) because, as M. Wood's comments indicate, these two samples are duplicates of 'SFEI-SacFish' samples *#00-1393/1390 comp3* and *#00-1393/1390 comp1*.
2. SRWP2: We entered ID# 00-1129 (Aug 4, 2004) for brown trout sample (Upper Putah Creek) and ID #00-1388 (Aug 11, 2004) for largemouth bass (Putah Creek). Per Excel file from R. Brodberg "1997-2001 SRWP Fish Data" and electronic CALFED data received from Ben Greenfield (w/o moisture).
3. UC Davis: 1997-1998 (0.7 mile d/s UCD) entry is incorrect entry as "Channel Catfish." It is Clam (*Proptera*) per Slotton data. (M. Gassel verified with S. Ayers: "As I remember this was just a single clam. 75x56 would be the length and width of the shell in millimeters.") S. Roberts entered 75 mm for Clam *Proptera* (n=1) and will change M. Wood's Region 5 dataset.
4. We changed the 'SampleDateTime' format from a text format to a consistent date format in order for the CDFG Channel and White Catfish from Putah Creek and Pope Creek Arms and all of the TSM collection dates to be transferred accurately into other programs.
5. UC Davis: We changed Sacramento Blackfish—weight 315, n=1, year=1998 from Putah Creek/Road106A—from 384mm to 284mm to agree with D. Slotton data.
6. TSM2: We changed 'sucker' to Sacramento Sucker for Putah Creek/South Fork Sample TSM2 (State Water Resources Control Board, Mar 2004 download).
7. We changed SFEI=CALFED #00-1391/00-1389 comp Sacramento Sucker from n=1 (M. Wood) to n=3 (per B. Greenfield's electronic data file sent to M. Gassel) and length from 256mm to 359mm (per B. Greenfield). In addition, this sample is attributed to SFEI CALFED and not to SFEI SacFish even though it was sampled in year 2000. All other CALFED data were sampled in 1999, and all SacFish data were sampled in year 2000.
8. E-data from B. Greenfield w/moisture: SFEI CALFED included ID#99-1239-t Sacramento Sucker which we did not include in this Lake Berryessa/Putah Creek data set because mercury was not measured.
9. UC Davis from Slotton et al. "Lower Putah Creek 1997-1998 Mercury Biological Distribution Study…." We corrected ten crayfish lengths and weights, which were transposed.
10. UC Davis: We added 5 crayfish samples—at Putah Creek in Lake Solano—from S. Ayers E-data.
11. TSM: We did not include TSMP composite (n=30) of sculpin from 1980 because average length does not meet OEHHA minimum.

M. Wood project labels changed to corresponding projects:

M. Wood Label	Refers to	OEHHA Label
SRWP	Sacramento River Watershed Program 1997-1999	SRWP
SRWP2	Sacramento River Watershed Program 2000	SRWP
SFEI CALFED	CALFED Mercury Project	CALFED
SFEI SacFish	Sacramento River Watershed Program	SRWP
UC Davis	Lower Putah Creek 1997-1998 Mercury Biological Distribution Study	UC Davis
TSM	Toxic Substances Monitoring Program 1978-1997	TSMP
TSM2	TSMP 1998-2000	TSMP

Appendix V: Case Summaries for Fish and Shellfish Samples from Lake Berryessa and Putah Creek

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Black Crappie	UC Davis	1998	Putah Creek/Pedrick Road	1	.	192.0	103.00	.330	1
Bluegill	CALFED	1999	Lake Berryessa/Pope Creek	2	170.0	.	98.00	.379	1
Bluegill	CALFED	1999	Lake Berryessa/Pope Creek	1	206.0	.	152.00	.416	1
Bluegill	CALFED	1999	Putah Creek	5	112.0	.	20.00	.097	1
Bluegill	CALFED	1999	Putah Creek	5	135.0	.	45.00	.123	1
Bluegill	SRWP	2000	Putah Creek	5	147.0	.	.	.071	1
Bluegill	SRWP	2000	Putah Creek	5	148.0	.	.	.096	1
Bluegill	SRWP	2000	Putah Creek	5	150.0	.	.	.158	1
Bluegill	SRWP	2000	Putah Creek	5	157.0	.	.	.165	1
Bluegill	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	104.0	22.00	.120	1
Bluegill	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	109.0	29.00	.250	1
Bluegill	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	117.0	30.00	.160	1
Bluegill	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	119.0	35.00	.160	1
Bluegill	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	142.0	45.00	.330	1
Bluegill	UC Davis	1998	Putah Creek/Pedrick Road	1	.	135.0	50.00	.190	1
Bluegill	UC Davis	1998	Putah Creek/Pedrick Road	1	.	135.0	75.00	.200	1
Bluegill	UC Davis	1998	Putah Creek/Pedrick Road	1	.	140.0	55.00	.220	1
Bluegill	UC Davis	1998	Putah Creek/Pedrick Road	1	.	147.0	85.00	.140	1
Bluegill	UC Davis	1998	Putah Creek/Pedrick Road	1	.	148.0	85.00	.240	1
Bluegill	UC Davis	1998	Putah Creek/Pedrick Road	1	.	153.0	112.00	.180	1
Bluegill	UC Davis	1998	Putah Creek/Pedrick Road	1	.	177.0	112.00	.320	1
Brown Trout	SRWP2	2000	Putah Creek/Upper	5	300.8	.	.	.060	1
Carp	TSMP	1985	Lake Berryessa/Pope Creek	1	.	532.0	1874.70	.600	1
Carp	TSMP	1985	Lake Berryessa/Putah Creek	1	.	483.0	1962.00	.480	1
Carp	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	311.0	555.00	.160	1
Carp	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	398.0	1060.00	.120	1
Carp	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	429.0	1450.00	.220	1
Carp	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	460.0	2025.00	.150	1
Carp	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	525.0	2800.00	.130	1

[1] A "1" signifies data that were legal and/or edible size and therefore selected; "0" indicates data that did not meet minimum size criteria and thus were not used.

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Carp	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	541.0	3300.00	.210	1
Carp	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	620.0	4900.00	.210	1
Carp	UC Davis	1998	Putah Creek/Pedrick Road	1	.	435.0	1520.00	.220	1
Carp	UC Davis	1998	Putah Creek/Road 106A	1	.	333.0	535.00	.230	1
Carp	UC Davis	1998	Putah Creek/Road 106A	1	.	362.0	805.00	.140	1
Carp	UC Davis	1998	Putah Creek/Road 106A	1	.	402.0	1210.00	.150	1
Carp	UC Davis	1998	Putah Creek/Road 106A	1	.	411.0	1040.00	.150	1
Carp	UC Davis	1998	Putah Creek/Road 106A	1	.	427.0	1440.00	.160	1
Carp	UC Davis	1998	Putah Creek/Road 106A	1	.	432.0	1280.00	.200	1
Carp	UC Davis	1998	Putah Creek/Road 106A	1	.	457.0	1750.00	.250	1
Channel Catfish	TSMP	1985	Lake Berryessa/Capell Creek	1	.	187.0	78.40	.110	1
Channel Catfish	TSMP	1985	Lake Berryessa/Capell Creek	1	.	298.0	264.40	.320	1
Channel Catfish	TSMP	1985	Lake Berryessa/Capell Creek	1	.	303.0	295.30	.200	1
Channel Catfish	TSMP	1985	Lake Berryessa/Capell Creek	1	.	317.0	372.30	.210	1
Channel Catfish	TSMP	1985	Lake Berryessa/Capell Creek	1	.	343.0	476.30	.140	1
Channel Catfish	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	235.0	125.40	.530	1
Channel Catfish	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	240.0	143.50	.690	1
Channel Catfish	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	293.0	262.80	.260	1
Channel Catfish	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	387.0	660.00	.210	1
Channel Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	195.0	82.70	.120	1
Channel Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	216.0	98.80	.600	1
Channel Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	220.0	120.40	.570	1
Channel Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	227.0	122.80	.400	1
Channel Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	233.0	130.40	.500	1
Channel Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	260.0	172.30	.410	1
Channel Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	272.0	244.60	.250	1
Channel Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	284.0	235.30	.230	1
Channel Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	297.0	280.50	.510	1
Channel Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	299.0	289.20	.260	1
Channel Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	318.0	312.40	.400	1
Channel Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	362.0	556.60	.390	1
Channel Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	379.0	601.30	.360	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	206.0	97.50	1.900	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	221.0	124.70	.380	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	224.0	126.20	.720	1

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	230.0	127.10	.450	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	233.0	141.50	.400	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	236.0	186.00	.250	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	238.0	152.70	.350	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	238.0	157.20	.400	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	239.0	163.74	.470	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	241.0	165.84	.570	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	241.0	156.34	.630	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	242.0	155.74	.450	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	246.0	181.84	.300	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	254.0	201.44	.420	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	259.0	210.90	.270	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	261.0	218.40	.510	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	266.0	223.60	.290	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	269.0	245.80	.410	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	280.0	244.30	.330	1
Channel Catfish	CDFG	1983	Lake Berryessa/East Shore Vineyards Area	1	.	305.0	376.40	.340	1
Channel Catfish	TSMP	1985	Lake Berryessa/Pope Creek	1	.	264.0	191.50	.410	1
Channel Catfish	TSMP	1985	Lake Berryessa/Pope Creek	1	.	265.0	200.60	.520	1
Channel Catfish	TSMP	1985	Lake Berryessa/Pope Creek	1	.	292.0	271.10	.500	1
Channel Catfish	TSMP	1985	Lake Berryessa/Pope Creek	1	.	304.0	310.00	.510	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	158.0	42.40	.260	0
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	193.0	83.20	.800	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	201.0	87.10	.800	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	210.0	92.10	.750	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	211.0	105.90	.700	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	219.0	121.20	.540	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	226.0	103.00	.540	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	228.0	118.50	.550	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	234.0	132.00	.490	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	235.0	136.70	.660	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	237.0	148.00	.760	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	239.0	161.20	.260	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	239.0	137.40	.610	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	248.0	148.90	.650	1

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	252.0	176.80	.500	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	257.0	177.90	.560	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	274.0	224.50	.490	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	380.0	616.90	.600	1
Channel Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	466.0	1323.30	.780	1
Channel Catfish	TSMP	1985	Lake Berryessa/Putah Creek	1	.	266.0	207.40	.300	1
Channel Catfish	TSMP	1985	Lake Berryessa/Putah Creek	1	.	306.0	319.80	.210	1
Channel Catfish	TSMP	1985	Lake Berryessa/Putah Creek	1	.	318.0	353.80	.340	1
Channel Catfish	TSMP	1985	Lake Berryessa/Putah Creek	1	.	377.0	346.70	.170	1
Channel Catfish	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	260.0	186.60	.450	1
Channel Catfish	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	280.0	266.50	.440	1
Channel Catfish	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	283.0	245.10	.360	1
Channel Catfish	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	286.0	259.90	.480	1
Channel Catfish	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	310.0	311.80	.300	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	208.0	101.60	.590	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	212.0	99.60	.820	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	216.0	111.20	.660	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	219.0	98.90	.600	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	220.0	112.80	.550	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	220.0	100.40	.560	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	220.0	104.50	.640	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	220.0	124.20	.720	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	220.0	115.30	.760	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	227.0	129.00	.680	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	228.0	124.00	.550	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	229.0	138.50	.600	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	230.0	126.40	.660	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	232.0	124.80	.730	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	234.0	126.10	.310	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	234.0	137.70	.310	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	235.0	120.80	.560	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	235.0	127.10	.630	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	239.0	143.60	.700	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	240.0	134.70	.830	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	242.0	152.90	.670	1

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	243.0	143.90	.690	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	243.0	163.40	.910	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	244.0	145.60	.520	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	245.0	152.40	.420	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	245.0	160.70	.760	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	246.0	167.40	.390	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	246.0	144.70	.510	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	246.0	151.50	1.190	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	250.0	149.90	.780	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	252.0	173.20	.510	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	254.0	186.00	.670	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	255.0	151.90	.520	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	257.0	154.50	.900	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	263.0	206.60	.330	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	264.0	181.60	.690	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	265.0	184.20	.980	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	266.0	187.90	.330	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	276.0	232.20	.450	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	282.0	240.50	.450	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	285.0	239.70	.420	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	299.0	297.10	.220	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	309.0	301.50	.610	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	330.0	406.30	.510	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	371.0	570.00	.750	1
Channel Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	390.0	736.50	.410	1
Channel Catfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	294.0	310.00	.090	1
Channel Catfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	310.0	340.00	.100	1
Channel Catfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	539.0	2700.00	.200	1
Channel Catfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	256.0	205.00	.130	1
Channel Catfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	365.0	710.00	.340	1
Channel Catfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	378.0	750.00	.110	1
Channel Catfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	413.0	1280.00	.170	1
Channel Catfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	437.0	1110.00	.230	1
Channel Catfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	470.0	1570.00	.120	1
Channel Catfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	500.0	1970.00	.180	1

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Channel Catfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	510.0	1660.00	.070	1
Channel Catfish	UC Davis	1998	Putah Creek/Road 106A	1	.	349.0	480.00	.080	1
Channel Catfish	UC Davis	1998	Putah Creek/Road 106A	1	.	394.0	740.00	.070	1
Clam	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	75.0	.	.	.030	0
Green Sunfish	UC Davis	1998	Putah Creek/d/s Winters	1	.	108.0	25.00	.150	1
Green Sunfish	UC Davis	1998	Putah Creek/d/s Winters	1	.	108.0	23.00	.190	1
Hitch	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	274.0	305.00	.100	1
Hitch	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	278.0	315.00	.070	1
Hitch	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	288.0	345.00	.090	1
Hitch	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	294.0	355.00	.080	1
Hitch	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	306.0	360.00	.110	1
Chinook (king) Salmon	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	340.0	588.60	.200	1
Chinook (king) Salmon	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	417.0	739.20	.410	1
Chinook (king) Salmon	CDFG	1984	Lake Berryessa/Small Trib To Marklee Cove	1	.	460.0	1277.80	.300	1
Chinook (king) Salmon	CDFG	1984	Lake Berryessa/Small Trib To Marklee Cove	1	.	465.0	1014.70	.700	1
Chinook (king) Salmon	CDFG	1984	Lake Berryessa/Small Trib To Marklee Cove	1	.	480.0	1319.80	.500	1
Chinook (king) Salmon	CDFG	1984	Lake Berryessa/Small Trib To Marklee Cove	1	.	480.0	1122.20	.600	1
Chinook (king) Salmon	CDFG	1984	Lake Berryessa/Small Trib To Marklee Cove	1	.	490.0	1223.20	.500	1
Chinook (king) Salmon	CDFG	1984	Lake Berryessa/Small Trib To Marklee Cove	1	.	490.0	1216.50	.600	1
Chinook (king) Salmon	CDFG	1984	Lake Berryessa/Small Trib To Marklee Cove	1	.	490.0	1465.10	.600	1
Chinook (king) Salmon	CDFG	1984	Lake Berryessa/Small Trib To Marklee Cove	1	.	500.0	1476.30	.400	1
Chinook (king) Salmon	CDFG	1984	Lake Berryessa/Small Trib To Marklee Cove	1	.	510.0	1363.70	.500	1
Largemouth Bass	TSMP	1985	Lake Berryessa/Capell Creek	1	.	270.0	317.00	.200	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	98.0	16.20	.100	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	104.0	18.40	.080	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	105.0	20.00	.130	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	114.0	26.40	.060	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	120.0	28.90	.080	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	194.0	119.70	.210	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	195.0	140.40	.110	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	202.0	130.60	.150	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	226.0	190.30	.180	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	232.0	224.60	.210	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	233.0	198.20	.160	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	275.0	337.60	.340	0

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	330.0	550.20	.700	1
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	335.0	647.60	.740	1
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	373.0	801.80	1.100	1
Largemouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	406.0	1057.40	.950	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	254.0	289.50	.080	0
Largemouth Bass	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	297.0	473.90	.100	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	314.0	599.80	.120	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	325.0	636.10	.230	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	330.0	620.20	.230	1
Largemouth Bass	TSMP	1985	Lake Berryessa/Pope Creek	1	.	277.0	328.70	.370	0
Largemouth Bass	TSMP	1985	Lake Berryessa/Pope Creek	1	.	288.0	390.90	.210	0
Largemouth Bass	TSMP	1985	Lake Berryessa/Pope Creek	1	.	478.0	2005.70	1.620	1
Largemouth Bass	CALFED	1999	Lake Berryessa/Pope Creek	9	60.0	.	3.40	.095	0
Largemouth Bass	CALFED	1999	Lake Berryessa/Pope Creek	1	310.0	.	401.00	.779	1
Largemouth Bass	CALFED	1999	Lake Berryessa/Pope Creek	1	340.0	.	505.00	.877	1
Largemouth Bass	CALFED	1999	Lake Berryessa/Pope Creek	1	342.0	.	480.00	.726	1
Largemouth Bass	CALFED	1999	Lake Berryessa/Pope Creek	1	382.0	.	681.00	1.370	1
Largemouth Bass	CALFED	1999	Lake Berryessa/Pope Creek	1	396.0	.	679.00	1.130	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	290.0	429.00	.510	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	290.0	453.40	.510	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	295.0	412.70	.610	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	295.0	460.20	.670	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	300.0	435.50	.370	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	300.0	434.00	.660	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	305.0	465.40	.540	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	325.0	541.40	.620	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	325.0	524.00	.960	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	335.0	574.60	.710	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	365.0	790.30	1.040	1
Largemouth Bass	TSMP	1985	Lake Berryessa/Putah Creek	1	.	210.0	140.80	.170	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	122.0	29.20	.120	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	134.0	41.20	.130	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	197.0	130.10	.200	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	207.0	154.60	.250	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	219.0	173.40	.240	0

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Largemouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	219.0	177.30	.300	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	224.0	198.10	.330	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	250.0	269.60	.260	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	274.0	353.20	.590	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	288.0	349.70	.440	0
Largemouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	363.0	738.30	1.070	1
Largemouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	412.0	1216.40	.840	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	237.0	199.60	.150	0
Largemouth Bass	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	242.0	219.50	.190	0
Largemouth Bass	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	358.0	760.00	.560	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	377.0	967.20	.440	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	394.0	1099.30	.420	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	430.0	1307.70	.850	1
Largemouth Bass	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	538.0	2516.50	1.930	1
Largemouth Bass	CALFED	1999	Putah Creek	9	62.0	.	2.80	.050	0
Largemouth Bass	CALFED	1999	Putah Creek	1	345.0	.	558.00	.231	1
Largemouth Bass	CALFED	1999	Putah Creek	1	354.0	.	583.00	.396	1
Largemouth Bass	CALFED	1999	Putah Creek	1	402.0	.	986.00	.630	1
Largemouth Bass	CALFED	1999	Putah Creek	1	410.0	.	1022.00	.540	1
Largemouth Bass	CALFED	1999	Putah Creek	1	425.0	.	1131.00	.592	1
Largemouth Bass	SRWP	2000	Putah Creek	1	210.0	.	.	.103	0
Largemouth Bass	SRWP	2000	Putah Creek	1	306.0	.	.	.276	1
Largemouth Bass	SRWP	2000	Putah Creek	1	319.0	.	.	.340	1
Largemouth Bass	SRWP	2000	Putah Creek	1	324.0	.	.	.258	1
Largemouth Bass	SRWP	2000	Putah Creek	1	326.0	.	.	.222	1
Largemouth Bass	SRWP	2000	Putah Creek	1	342.0	.	.	.338	1
Largemouth Bass	SRWP	2000	Putah Creek	1	376.0	.	.	.452	1
Largemouth Bass	SRWP	2000	Putah Creek	1	384.0	.	.	.569	1
Largemouth Bass	SRWP	2000	Putah Creek	1	385.0	.	.	.502	1
Largemouth Bass	SRWP	2000	Putah Creek	1	390.0	.	.	.638	1
Largemouth Bass	SRWP	2000	Putah Creek	1	409.0	.	.	.816	1
Largemouth Bass	SRWP2	2000	Putah Creek	8	348.0	.	.	.450	1
Largemouth Bass	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	321.0	705.00	.200	1
Largemouth Bass	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	342.0	635.00	.230	1
Largemouth Bass	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	394.0	1120.00	.340	1

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Largemouth Bass	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	474.0	1920.00	.620	1
Largemouth Bass	UC Davis	1998	Putah Creek/d/s Winters	1	.	194.0	110.00	.150	0
Largemouth Bass	UC Davis	1998	Putah Creek/Pedrick Road	1	.	160.0	52.00	.340	0
Largemouth Bass	UC Davis	1998	Putah Creek/Road 106A	1	.	385.0	970.00	.630	1
Largemouth Bass	UC Davis	1998	Putah Creek/Road 106A	1	.	387.0	930.00	.730	1
Largemouth Bass	TSMP	1999	Putah Creek/South Fork	5	.	387.0	856.10	.478	1
Northern crayfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	48.0	.	39.30	.310	1
Northern crayfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	48.0	.	40.20	.360	1
Northern crayfish	UC Davis	1998	Putah Creek/LEHR/UC Davis	1	47.0	.	36.70	.220	1
Northern crayfish	UC Davis	1998	Putah Creek/LEHR/UC Davis	1	47.0	.	39.40	.260	1
Northern crayfish	UC Davis	1998	Putah Creek/LEHR/UC Davis	1	48.0	.	35.70	.190	1
Northern crayfish	UC Davis	1998	Putah Creek/Pedrick Road	1	31.0	.	8.80	.180	1
Northern crayfish	UC Davis	1998	Putah Creek/Pedrick Road	1	43.0	.	26.00	.450	1
Northern crayfish	UC Davis	1998	Putah Creek/Road 106A	1	42.0	.	24.70	.270	1
Northern crayfish	UC Davis	1998	Putah Creek/Russell Ranch	1	39.0	.	20.50	.220	1
Northern crayfish	UC Davis	1998	Putah Creek/Russell Ranch	1	39.0	.	21.50	.320	1
Northern crayfish	UC Davis	1998	Putah Creek/Russell Ranch	1	42.0	.	25.20	.520	1
Northern crayfish	UC Davis	1998	Putah Creek/Russell Ranch	1	43.0	.	26.00	.220	1
Northern crayfish	UC Davis	1998	Putah Creek/Russell Ranch	1	44.0	.	28.00	.290	1
Northern crayfish	UC Davis	1998	Putah Creek/Russell Ranch	1	45.0	.	35.10	.410	1
Northern crayfish	UC Davis	1998	Putah Creek/Russell Ranch	1	46.0	.	33.50	.490	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	295.0	273.80	.180	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	307.0	510.70	.130	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	313.0	349.60	.160	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	319.0	469.10	.250	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	320.0	417.00	.210	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	321.0	436.70	.190	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	322.0	499.50	.170	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	326.0	510.50	.150	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	329.0	436.40	.120	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	330.0	510.10	.170	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	340.0	568.80	.130	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	341.0	555.50	.120	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	346.0	627.80	.110	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	350.0	649.20	.160	1

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	351.0	559.40	.120	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	351.0	589.60	.150	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	354.0	633.00	.130	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	355.0	613.00	.170	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	370.0	773.60	.180	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	397.0	819.50	.110	1
Rainbow Trout	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	273.0	241.60	.210	1
Rainbow Trout	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	323.0	391.90	.220	1
Rainbow Trout	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	330.0	382.60	.180	1
Rainbow Trout	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	383.0	782.90	.190	1
Rainbow Trout	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	408.0	1001.90	.260	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	301.0	410.90	.120	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	302.0	240.20	.260	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	307.0	342.20	.200	1
Rainbow Trout	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	317.0	290.90	.250	1
Rainbow Trout	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	.	192.0	82.00	.070	0
Rainbow Trout	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	.	225.0	159.00	.070	1
Rainbow Trout	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	.	245.0	205.00	.060	1
Rainbow Trout	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	.	259.0	215.00	.070	1
Rainbow Trout	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	.	337.0	425.00	.050	1
Rainbow Trout	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	.	348.0	505.00	.080	1
Rainbow Trout	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	.	383.0	580.00	.150	1
Rainbow Trout	UC Davis	1998	Putah Creek/d/s Lake Solano	1	.	166.0	60.00	.120	0
Rainbow Trout	UC Davis	1998	Putah Creek/d/s Lake Solano	1	.	185.0	75.00	.090	0
Rainbow Trout	UC Davis	1998	Putah Creek/d/s Lake Solano	1	.	189.0	72.00	.100	0
Rainbow Trout	UC Davis	1998	Putah Creek/d/s Lake Solano	1	.	193.0	105.00	.080	0
Red swamp crayfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	47.0	.	26.70	.200	1
Red swamp crayfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	48.0	.	36.90	.150	1
Red swamp crayfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	50.0	.	39.50	.200	1
Red swamp crayfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	55.0	.	36.50	.190	1
Red swamp crayfish	UC Davis	1998	Putah Creek/LEHR/UC Davis	1	41.0	.	20.20	.100	1
Red swamp crayfish	UC Davis	1998	Putah Creek/LEHR/UC Davis	1	43.0	.	27.20	.100	1
Red swamp crayfish	UC Davis	1998	Putah Creek/LEHR/UC Davis	1	45.0	.	22.60	.100	1
Red swamp crayfish	UC Davis	1998	Putah Creek/LEHR/UC Davis	1	48.0	.	32.10	.140	1
Red swamp crayfish	UC Davis	1998	Putah Creek/LEHR/UC Davis	1	48.0	.	28.50	.180	1

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Red swamp crayfish	UC Davis	1998	Putah Creek/LEHR/UC Davis	1	52.0	.	31.70	.140	1
Red swamp crayfish	UC Davis	1998	Putah Creek/LEHR/UC Davis	1	54.0	.	35.40	.100	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Mace Blvd.	1	46.0	.	24.80	.140	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Mace Blvd.	1	48.0	.	29.80	.190	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Mace Blvd.	1	49.0	.	36.20	.170	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Mace Blvd.	1	51.0	.	39.10	.140	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Mace Blvd.	1	52.0	.	40.70	.170	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Pedrick Road	1	31.0	.	8.90	.050	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Pedrick Road	1	37.0	.	11.40	.060	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Pedrick Road	1	43.0	.	17.00	.130	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Pedrick Road	1	45.0	.	20.00	.120	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Pedrick Road	1	45.0	.	25.60	.120	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Pedrick Road	1	45.0	.	18.90	.280	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Pedrick Road	1	49.0	.	26.20	.220	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Pedrick Road	1	50.0	.	25.10	.170	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Pedrick Road	1	53.0	.	43.20	.170	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Road 106A	1	33.0	.	9.10	.160	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Road 106A	1	35.0	.	10.80	.070	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Road 106A	1	40.0	.	14.50	.100	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Road 106A	1	47.0	.	25.30	.120	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Road 106A	1	49.0	.	27.50	.180	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Road 106A	1	56.0	.	43.20	.120	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Russell Ranch	1	30.0	.	5.00	.060	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Russell Ranch	1	43.0	.	20.60	.100	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Russell Ranch	1	51.0	.	33.40	.100	1
Red swamp crayfish	UC Davis	1998	Putah Creek/Russell Ranch	1	52.0	.	28.30	.140	1
Redear Sunfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	192.0	153.00	.150	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	272.0	290.00	.040	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	311.0	430.00	.050	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	319.0	505.00	.050	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	354.0	685.00	.070	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	355.0	555.00	.090	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	365.0	820.00	.110	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	377.0	790.00	.070	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	419.0	1140.00	.080	1

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Sacramento Blackfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	335.0	580.00	.060	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	335.0	630.00	.090	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	366.0	700.00	.090	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	379.0	920.00	.090	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/Pedrick Road	1	.	397.0	1000.00	.100	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/Road 106A	1	.	276.0	285.00	.070	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/Road 106A	1	.	284.0	315.00	.080	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/Road 106A	1	.	303.0	385.00	.070	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/Road 106A	1	.	303.0	355.00	.120	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/Road 106A	1	.	338.0	505.00	.060	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/Road 106A	1	.	367.0	600.00	.230	1
Sacramento Blackfish	UC Davis	1998	Putah Creek/Road 106A	1	.	398.0	840.00	.140	1
Sacramento Pikeminnow	UC Davis	1998	Putah Creek/Road 106A	1	.	252.0	165.00	.720	1
Sacramento Pikeminnow	UC Davis	1998	Putah Creek/Road 106A	1	.	318.0	250.00	.730	1
Sacramento Pikeminnow	UC Davis	1998	Putah Creek/Russell Ranch	1	.	232.0	107.00	.170	0
Sacramento Pikeminnow	UC Davis	1998	Putah Creek/Russell Ranch	1	.	257.0	135.00	.260	1
Sacramento Pikeminnow	UC Davis	1998	Putah Creek/Russell Ranch	1	.	270.0	150.00	.290	1
Sacramento Pikeminnow	UC Davis	1998	Putah Creek/Russell Ranch	1	.	453.0	990.00	.480	1
Sacramento Sucker	CALFED	1999	Putah Creek	4	383.0	.	751.00	.185	1
Sacramento Sucker	CALFED	2000	Putah Creek	3	359.0	.	.	.170	1
Sacramento Sucker	UC Davis	1998	Putah Creek/d/s Lake Solano	1	.	335.0	430.00	.160	1
Sacramento Sucker	UC Davis	1998	Putah Creek/Pedrick Road	1	.	364.0	625.00	.130	1
Sacramento Sucker	UC Davis	1998	Putah Creek/Pedrick Road	1	.	377.0	470.00	.130	1
Sacramento Sucker	UC Davis	1998	Putah Creek/Russell Ranch	1	.	217.0	115.00	.100	1
Sacramento Sucker	UC Davis	1998	Putah Creek/Russell Ranch	1	.	371.0	550.00	.120	1
Sacramento Sucker	UC Davis	1998	Putah Creek/Russell Ranch	1	.	379.0	680.00	.110	1
Sacramento Sucker	UC Davis	1998	Putah Creek/Russell Ranch	1	.	388.0	800.00	.180	1
Sacramento Sucker	UC Davis	1998	Putah Creek/Russell Ranch	1	.	405.0	810.00	.130	1
Sacramento Sucker	UC Davis	1998	Putah Creek/Russell Ranch	1	.	408.0	860.00	.110	1
Sacramento Sucker	TSMP	1999	Putah Creek/South Fork	4	.	383.0	751.40	.185	1
Signal crayfish	UC Davis	1998	Putah Creek in Lake Solano	1	36.0	.	15.70	.180	1
Signal crayfish	UC Davis	1998	Putah Creek in Lake Solano	1	37.0	.	19.50	.230	1
Signal crayfish	UC Davis	1998	Putah Creek in Lake Solano	1	47.0	.	38.20	.200	1
Signal crayfish	UC Davis	1998	Putah Creek in Lake Solano	1	49.0	.	48.20	.260	1
Signal crayfish	UC Davis	1998	Putah Creek in Lake Solano	1	53.0	.	53.40	.270	1

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	31.0	.	10.90	.110	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	34.0	.	14.40	.450	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	39.0	.	18.20	.440	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	45.0	.	31.70	.140	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	45.0	.	38.30	.330	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	46.0	.	36.80	.350	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	47.0	.	37.00	.240	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	48.0	.	26.20	.610	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	55.0	.	70.40	.510	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Berryessa	1	60.0	.	97.70	.220	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Solano	1	37.0	.	17.50	.120	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Solano	1	47.0	.	40.40	.160	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Solano	1	50.0	.	42.50	.130	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Solano	1	51.0	.	47.10	.160	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Solano	1	51.0	.	38.60	.180	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Solano	1	53.0	.	57.50	.230	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Solano	1	53.0	.	54.90	.290	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Lake Solano	1	60.0	.	71.50	.340	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Winters	1	48.0	.	36.60	.110	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Winters	1	50.0	.	36.70	.100	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Winters	1	51.0	.	49.30	.130	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Winters	1	54.0	.	56.60	.080	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Winters	1	56.0	.	57.60	.280	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Winters	1	64.0	.	95.70	.210	1
Signal crayfish	UC Davis	1998	Putah Creek/d/s Winters	1	66.0	.	106.20	.170	1
Smallmouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	163.0	70.00	.200	0
Smallmouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	183.0	107.50	.250	0
Smallmouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	195.0	120.50	.160	0
Smallmouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	196.0	122.90	.210	0
Smallmouth Bass	CDFG	1982	Lake Berryessa/Capell Creek Arm	1	.	210.0	130.60	.200	0
Smallmouth Bass	CDFG	1982	Lake Berryessa/Pope Creek Arm	1	.	340.0	550.00	.930	1
Smallmouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	113.0	24.80	.160	0
Smallmouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	115.0	24.30	.080	0
Smallmouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	132.0	38.60	.220	0
Smallmouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	135.0	50.90	.180	0

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
Smallmouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	148.0	53.00	.190	0
Smallmouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	202.0	156.40	.250	0
Smallmouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	212.0	164.10	.290	0
Smallmouth Bass	CDFG	1982	Lake Berryessa/Putah Creek Arm	1	.	284.0	374.40	.590	0
Smallmouth Bass	UC Davis	1998	Putah Creek/Pedrick Road	1	.	209.0	100.00	.350	0
Smallmouth Bass	UC Davis	1998	Putah Creek/Russell Ranch	1	.	143.0	40.00	.250	0
Sunfish (hybrid)	UC Davis	1998	Putah Creek/Pedrick Road	1	.	178.0	131.00	.190	1
White Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	186.0	85.90	.910	1
White Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	200.0	94.80	.700	1
White Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	212.0	120.60	.540	1
White Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	213.0	128.20	.510	1
White Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	214.0	123.70	1.020	1
White Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	215.0	124.50	.680	1
White Catfish	CDFG	1983	Lake Berryessa/Capell Creek Arm	1	.	237.0	188.90	.670	1
White Catfish	CALFED	1999	Lake Berryessa/Pope Creek	1	520.0	.	1383.00	1.020	1
White Catfish	CDFG	1983	Lake Berryessa/Pope Creek Arm	1	.	180.0	79.40	.700	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	184.0	88.70	.840	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	191.0	105.30	.590	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	193.0	104.20	.840	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	201.0	114.70	.720	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	202.0	117.00	.910	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	202.0	106.40	.960	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	206.0	110.40	.540	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	213.0	131.60	.730	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	215.0	125.10	.900	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	216.0	117.30	.770	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	217.0	123.20	.910	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	219.0	139.90	.880	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	224.0	150.80	.790	1
White Catfish	CDFG	1983	Lake Berryessa/Putah Creek Arm	1	.	241.0	203.70	.660	1
White Catfish	CALFED	1999	Putah Creek	1	470.0	.	1111.00	.146	1
White Catfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	332.0	595.00	.130	1
White Catfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	340.0	610.00	.190	1
White Catfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	348.0	655.00	.120	1
White Catfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	359.0	720.00	.130	1

Common Name	Project ID	Year	Site	Number	Total Length (mm)	Fork Length (mm)	Weight (g)	Mercury (ppm wet wt)	Edible/legal Size[1]
White Catfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	360.0	745.00	.100	1
White Catfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	413.0	1310.00	.110	1
White Catfish	UC Davis	1998	Putah Creek/~0.7 mile d/s UC Davis	1	.	431.0	1390.00	.160	1
White Catfish	UC Davis	1998	Putah Creek/Road 106A	1	.	320.0	545.00	.180	1
White Crappie	UC Davis	1998	Putah Creek/Pedrick Road	1	.	165.0	48.00	.190	1
White Crappie	UC Davis	1998	Putah Creek/Pedrick Road	1	.	167.0	50.00	.150	1
White Crappie	UC Davis	1998	Putah Creek/Pedrick Road	1	.	190.0	83.00	.160	1
White Crappie	UC Davis	1998	Putah Creek/Road 106A	1	.	359.0	735.00	.630	1

Appendix VI. Descriptive Statistics for Mercury Concentrations (ppm, wet weight) and Length (mm) from Lake Berryessa

Descriptive Statistics[1] for Mercury Concentration (ppm, wet weight) and Length (mm)[2] from Lake Berryessa

	Mercury ppm						*Total Length mm*[2]						*Sample Size*			
Species	*Mean*	*Median*	*SD*	Min	*Max*	*CI*	*Mean*	*Median*	*SD*	Min	*Max*	*CI*	*1 indiv/sample*	*2 indiv/sample*	*Total # samples*	*Total N*
Bluegill	.39	.38	.02	.38	.42	.34-.44	182	170	21	170	206	130-234	1	1	2	3
Carp	.54	.54	.08	.48	.60	.00-1.30	558	558	38	531	585	216-901	2	0	2	2
Channel Catfish	.52	.51	.23	.11	1.90	.47-.56	300	283	54	215	536	290-310	119	0	119	119
Chinook (king) Salmon	.48	.50	.15	.20	.70	.38-.58	489	504	51	357	536	455-523	11	0	11	11
Largemouth Bass	.75	.71	.40	.10	1.93	.60-.90	367	347	60	305	565	345-388	32	0	32	32
Rainbow Trout	.17	.17	.05	.11	.26	.15-.19	342	337	31	280	418	330-354	29	0	29	29
Smallmouth Bass	.93	.93	NA	.93	.93	NA	357	357	NA	357	357	NA	1	0	1	1
White Catfish	.77	.77	.15	.51	1.02	.71-.84	242	234	63	198	520	214-269	23	0	23	23

[1] Data weighted by number of individuals per sample.

[2] Type of length is total length—longest length from tip of tail fin to tip of nose/mouth. TSMP and CDFG samples were converted to total lengths per OEHHA PETS conversion factors, *i.e.*, fork length times 1.05 for bluegill, chinook (king) salmon, largemouth and smallmouth bass; times 1.15 for channel catfish; times 1.1 for white catfish; and times 1.025 for rainbow trout. Length values for composite samples are reported as mean length.

NA: Confidence Interval and Standard Deviation are not applicable since Mercury or Total length mm is constant.

Appendix VII. Descriptive Statistics for Mercury Concentration (ppm, wet weight) and Length (mm) from Putah Creek

Descriptive Statistics[1] for Mercury Concentration (ppm, wet weight) and Length (mm)[2] from Putah Creek																		
	Mercury ppm						*Total Length mm*[2]						*Sample Size*					
Species	*Mean*	*Median*	*SD*	Min	*Max*	*95% CI*	*Mean*	*Median*	*SD*	Min	*Max*	*95% CI*	*1 indiv/sample*	*3 indiv/sample*	*4 indiv/sample*	*5 indiv/sample*	*8 indiv/sample*	`otal # amples	*Total N*
Bluegill	.14	.13	.06	.07	.33	.13-.16	142	147	17	109	186	136-147	12	0	0	6	0	18	42
Carp	.18	.16	.04	.12	.25	.16-.20	480	472	88	342	682	431-528	15	0	0	0	0	15	15
Channel Catfish	.15	.12	.08	.07	.34	.10-.19	461	453	101	294	620	400-522	13	0	0	0	0	13	13
Largemouth Bass	.46	.45	.15	.20	.82	.41-.51	374	368	40	306	498	361-388	21	0	0	1	1	23	34
Northern Crayfish	.31	.29	.11	.18	.52	.25-.37	43	44	5	31	48	41-46	15	0	0	0	0	15	15
Red Swamp Crayfish	.14	.14	.05	.05	.28	.12-.16	46	48	7	30	56	44-48	35	0	0	0	0	35	35
Sacramento Blackfish	.09	.08	.04	.04	.23	.07-.11	377	381	47	299	461	355-399	20	0	0	0	0	20	20
Sacramento Sucker	.16	.17	.03	.10	.19	.14-.17	393	404	46	239	449	372-415	9	1	2	0	0	12	20
Signal Crayfish	.24	.22	.13	.08	.61	.19-.29	49	50	8	31	66	46-52	30	0	0	0	0	30	30
White Catfish	.14	.13	.03	.10	.19	.12-.16	407	395	47	352	474	371-443	9	0	0	0	0	9	9

[1] Data weighted by number of individuals per sample.

[2] Type of length for crayfish is carapace length. For all other species, type of length is total length—longest length from tip of tail fin to tip of nose/mouth. TSMP and CDFG samples were converted to total lengths per OEHHA PETS conversion factors, *i.e.*, fork length times 1.03 for crappie; times 1.05 for bluegill, sunfish, and largemouth bass; times 1.1 for carp, hitch, blackfish, Sacramento pikeminnow, sucker, and white catfish; times 1.15 for channel catfish, and times 1.025 for rainbow trout. All brown trout were reported as total length. Length values for composite samples are reported as mean length.

NA: Confidence Interval and Standard Deviation are not applicable since Mercury or Total length mm is constant.

Appendix VII. Descriptive Statistics for Mercury Concentration (ppm, wet weight) and Length (mm) from Putah Creek -- CONTINUED

Descriptive Statistics[1] for Mercury Concentration (ppm, wet weight) and Length (mm)[2] from Putah Creek																				
	Mercury ppm						*Total Length mm*[2]						*Sample Size*							
Species	*Mean*	*Median*	*SD*	*Min*	*Max*	*95% CI*	*Mean*	*Median*	*SD*	*Min*	*Max*	*95% CI*	*1 indiv/sample*	*3 indiv/sample*	*4 indiv/sample*	*5 indiv/sample*	*8 indiv/sample*	`otal # amples	*Total N*
Black Crappie	.33	.33	NA	.33	.33	NA	198	198	NA	198	198	NA	1	0	0	0	0	1	1
Brown Trout	.06	.06	NA	.06	.06	NA	301	301	NA	301	301	NA	0	0	0	1	0	1	5
Green Sunfish	.17	.17	.03	.15	.19	.00-.42	113	113	NA	113	113	NA	2	0	0	0	0	2	2
Hitch	.09	.09	.02	.07	.11	.07-.11	317	317	14	301	337	299-334	5	0	0	0	0	5	5
Rainbow Trout	.08	.07	.04	.05	.15	.04-.12	307	305	66	231	393	237-377	6	0	0	0	0	6	6
Redear Sunfish	.15	.15	NA	.15	.15	NA	202	202	NA	202	202	NA	1	0	0	0	0	1	1
Sacramento Pikeminnow	.50	.48	.23	.26	.73	.22-.78	341	297	93	277	498	226-456	5	0	0	0	0	5	5
Sunfish (hybrid)	.19	.19	NA	.19	.19	NA	187	187	NA	187	187	NA	1	0	0	0	0	1	1
White Crappie	.28	.18	.23	.15	.63	.00-.65	227	184	96	170	370	74-380	4	0	0	0	0	4	4

[1] Data weighted by number of individuals per sample.

[2] Type of length for crayfish is carapace length. For all other species, type of length is total length—longest length from tip of tail fin to tip of nose/mouth. TSMP and CDFG samples were converted to total lengths per OEHHA PETS conversion factors, *i.e.*, fork length times 1.03 for crappie; times 1.05 for bluegill, sunfish, and largemouth bass; times 1.1 for carp, hitch, blackfish, Sacramento pikeminnow, sucker, and white catfish; times 1.15 for channel catfish, and times 1.025 for rainbow trout. All brown trout were reported as total length. Length values for composite samples are reported as mean length.

NA: Confidence Interval and Standard Deviation are not applicable since Mercury or Total length mm is constant.